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AN
ESSAY
ON THE
CAUSES AND PHENOMENA
OF
ANIMAL LIFE.

BY
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EDINBURGH; AND J. JOHNSON, LONDON.

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WHEN considered in that extent of
 which the subject is susceptible,
 Medicine appears to be of the utmost con-
 sequence to mankind. But notwithstand-
 ing its importance, it does not seem to
 have been generally studied upon just
 principles: For the fact must be acknow-
 ledged, that the Healing Art has made
 a slower progress towards improvement
 than almost any other branch of Science.
 Whatever changes and new modifications
 the doctrines of Medicine may have un-
 dergone, medical practice has continued
 almost invariably the same, among every
 sect of Physicians, since the days of Hip-
 pocrates, till nearly the present time.

Since a just method of philosophizing
 has been employed, we observe a remark-

able change to have taken place in every department of Science. Reasoning from preconceived opinions, and vague hypotheses, has given place to conclusions founded upon the induction of facts which are either self-obvious, or established by the sure test of experiment. Guided by this unerring plan, truth has been made to triumph over error,—assumed theories, unsupported by facts, are in a great measure banished,—and the sciences, and arts connected with them, are respectively arrived at a degree of perfection proportioned to the extent in which such a mode of cultivation has been pursued.

It is however very generally admitted, and it is much to be regretted, that the same observations cannot with justice be applied to Medicine. Why has not the same rapid improvement been made in this science, as in other branches of philosophy? Are the principles of inductive philosophy inapplicable to Medicine? or have the generality of those who have pursued

fused this study, not availed themselves of these principles. To suppose that the same methods by which truth is discriminated from error in other branches of human knowledge, will not apply to the Healing Art, is an evident absurdity. The operations of Nature in the animal body, whether in the state of health or disease, are conducted according to fixed laws. It is certainly possible, from observation and experiment, to ascertain these laws; and from hence to deduce just rules for the preservation of health and cure of disease. It must however be confessed, that true philosophy has not at all times been employed in the prosecution of medical studies.

A few years only have elapsed, since an attempt was made by the late Dr John Brown, to apply the principles of modern science, for the cultivation of the Healing Art. It is not intended here to inquire, how far he succeeded in the execution of this important task. But there are

many reasons to conclude, that this author has been led into considerable mistakes, arising from his unlimited simplification of cause and effect. The fact however is indisputable, that this new system has produced a more remarkable revolution, both in the theoretical and practical departments of this branch of science, than is to be found throughout the whole history of Medicine. Under all the former doctrines of this Art, and under almost every modification of disease, we find an universal sameness in the method of cure. Bleeding, purging, vomiting, and every other mode of evacuation, were indiscriminately applied, in almost every disease: and even in those cases in which stimulants were employed, or an invigorating plan of cure pursued, these were frequently alternated with evacuations, as if certain diseases could not be eradicated, except by the opposite means of inducing debility and vigour at the same time in the body. Argument is certainly unnecessary to prove the impropriety

propriety of employing totally dissimilar powers to combat the same disease.

The practice founded on the new theory in one respect resembles the old, as the same method of cure is employed in the far greater number of diseases. The old theorists universally applied evacuants, and endeavoured to debilitate the system by every means. The application of stimulants is nearly as universal, on the principles of the new theory. According to the assertion of its author, this plan of cure ought to be employed in the proportion of ninety-seven diseases in the hundred. If this opinion is founded in the nature of things, what havock must have been produced by the opposite method during the course of two thousand years?

It is however to be feared, that, upon a moderate calculation, both the beneficial and pernicious tendency of either mode of practice is nearly in an equal ratio, in proportion to the time of their respective

respective reigns. Mankind hitherto have had a wonderful tendency towards rushing into extremes. In no case, perhaps, is this fact more fully exemplified, than in the instance now before us: For if (as has been asserted) the practice under the old theories has had a tendency more frequently to produce death than to cure disease, it is still perhaps problematical, whether that of more modern date does not, in many instances, produce the same effect, by employing an opposite cause. For there is reason to believe, that this practice has been carried to the extreme, by those who are acquainted with the principles upon which it is founded, and also by those who are guided merely by the universal principle of imitation. The method, however, which the author of it adopted, for analyzing the Healing Art, has been found of the utmost importance for prosecuting discoveries in every other branch of Science; and there are good grounds to hope, that by still pursuing the same plan with caution, Medicine will progressively

progressively become a most valuable acquisition to society.

To effect this important purpose, ought to be the chief business of every one who has devoted himself to the study of this science. That much still remains to be done, must be granted.

In the following Essay, an attempt has been made to state the Causes and Phenomena of Animal Life, and the various changes to which the body is liable, by the increased or diminished action of those powers which produce life, or of others to the operation of which the animal body may be subjected. An accurate knowledge of the causes by which animal life is produced and continued, and the various changes to which the body is liable, seems to be the basis upon which only a just medical theory and practice can be founded. With what success the subject has been treated, must be left to the determination of the reader. That it is in many

many respects deficient, arising from the brevity with which so extensive a subject has been treated, and from the imperfect state of our knowledge with regard to the laws of animated nature, the Author is ready to admit; and it may contain errors of which he is not conscious. If these are candidly pointed out, he will cheerfully submit to correction.

The Anatomical Part might, perhaps, in the opinion of some readers, have been spared. To the Author, however, it seemed absolutely necessary for the illustration of the subject. It is chiefly abstracted from modern writers, and, in some instances, almost literally.

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THE works of Nature, which may be properly comprehended under the two divisions of organic and inorganic matter, exhibit an almost infinite variety of productions, apparently dissimilar, yet so intimately connected, that each individual seems necessary to the whole. Under each of these forms we observe matter subjected to perpetual vicissitude. A series of decompositions, and of the formation of new bodies, regularly succeed each other. It is the business of philosophy to collect the various facts which nature offers

to our observation, and from a proper arrangement of these facts, on the principles of induction, to ascertain the general laws by which her operations are directed: or in other words, to discover those mutual relations which subsist between the various substances which form the natural world.

The changes which take place on inorganic matter, the decompositions which are effected, the new substances which are produced, with the forms and qualities which they assume, are known to depend upon what are termed the laws of chemical attraction or affinity. These are, in fact, immutable relations subsisting between the various species of matter. Two or more given bodies will, at all times, if placed in similar circumstances, exhibit the same phenomena. Anomalous cases of chemical attraction were indeed formerly supposed to exist; but in proportion to the increase of our knowledge upon this subject, by accurate investigation, these supposed anomalies have disappeared, and we have obtained the most convincing proofs

proofs that on inorganic matter nature operates by invariable laws.

The same uniformity of operation, we must necessarily conclude, takes place in the formation of organized substances, and in the production of the various phenomena which they exhibit. They are not governed by precisely the same, but by equally fixed and invariable laws. The formation of an organized body, whether animal or vegetable, and the production and continuance of that species of life which it possesses, with all its phenomena, depend on immutable relations subsisting between various species of matter.

The design in this essay is to institute an enquiry concerning the causes and phenomena of animal life, particularly in the human species. The importance of the subject will be generally admitted; for the preservation of health, and the cure of diseases, must materially depend upon a just knowledge of the causes by which the phenomena of life are produced and continued. In the prosecution of this sub-

ject I shall studiously avoid hypothetical opinions, and shall endeavour to deduce the theory which I hope to establish, from indisputable facts. Where the operations of nature elude our researches, we must necessarily close the enquiry.

The phenomena of life in the human species, have been attributed to the union of an immaterial substance to the corporeal frame. It is not intended here, to deny the existence of soul or spirit, whether purely immaterial, or otherwise; but we cannot admit that the animal life in the human species is produced by the presence of such a distinct substance, because we observe the same species of life, the same animal functions, possessed by the inferior orders of the animal kingdom. Something analogous to animal life is also sufficiently obvious in the vegetable kingdom, though in a lower degree; and no one, it is presumed, will be inclined to suppose the existence of spirit in vegetables. The notion of an animal soul, by which all the functions of body are directed,

directed, is mere hypothesis, unsupported by a single fact. The *archæus* of Van Helmont, and the *vis medicatrix naturæ* of later physiologists, whether intended to express substances distinct from body, or only certain powers possessed by organized matter, seem too much founded upon fancy to deserve a particular consideration.

In ascertaining the causes of animal life, it is necessary first to point out the criteria by which we distinguish animate from inanimate matter. These are, sensation, perception, and motion. By sensation, we mean distinct feelings of pain or pleasure, produced by the operation of various agents. By perception, we denote the consciousness of such feelings. The term motion it is unnecessary to explain. These properties we perceive existing in a greater or lesser degree in all animals. In man, and the other nobler animals, they exist in the highest degree. In the inferior orders, we observe the powers of life more circumscribed: yet, in as far as we perceive,

ceive, that they have organs similar to our own, and that when acted upon by certain powers, the same phenomena are produced in them as in ourselves, we must infer that they possess the same properties.

The existence of these properties, sensation, perception, and motion, are the sole criteria of life, and these are produced by the action of certain powers or agents.

The rays of light, reflected on the retina from any substance, produce the sensation called sight: the undulating motion of the air, arising from the vibrations of a sonorous body, produces the sensation of sound, or hearing: the contact of another substance constitutes feeling: and the operation of the mental function, or of any chemical or mechanical stimulus, on muscular fibre, produces motion. The possession of these properties distinguishes living from dead matter. Now we cannot account for these properties upon any mechanical principles; nor can the most accurate investigation of the structure or constituents of the animal body, discover the

the cause of that capacity which we observe in organized matter, of being thus acted upon by the different powers which excite motion or produce sensation. The anatomist may trace, and show, to a certain degree, the distribution of particular nerves, blood-vessels, and muscular fibres: the chemist may exhibit their constituents, by the last result of analysis: but however important their labours are in other respects, hitherto they have not thrown any light on that peculiar capacity, which we observe in animal bodies, of being acted upon; the consequence of which action is the production of the phenomena of life. We are reduced therefore to the necessity of concluding, that this capacity depends simply upon a peculiar organization: and that, by several modifications of that organization, the body is rendered, in its various parts, susceptible of the action of different powers, by which all the sensations and motions are excited. The most distinct notion that we can obtain of life, perhaps, is, that it is a state produced in organized bodies,

bodies, by the operation of certain agents. Mere organic structure is not sufficient to account for the phenomena of life: it is necessary that this organized matter should be acted upon by powers suited to its nature and structure, by which its sensations are awakened, and every part is excited to action. There is an immutable relation subsisting between the different powers or agents, and the organized bodies upon which they operate, depending on the peculiar nature of their organization. These powers act not, or at least act in a very different manner, upon inorganized matter. Their operation continues invariably the same upon organized substances while their structure remains unimpaired: but if the organization becomes deranged to a certain extent, these powers are no longer capable of producing the phenomena of life; and their action is precisely the same as upon inorganic matter.

If it is indeed true that we cannot ascertain the cause why organic matter is susceptible of the action of certain agents; if

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we can only perceive the effects of these agents upon organized substances, but in most instances cannot discover the mode of their operation; and if we can only estimate their beneficial or injurious powers, by the effects which follow their operation; it must remain as an ultimate fact, that the susceptibility which we observe in the animal body to be excited by certain powers, depends upon its peculiar organization.

The capacity which the body possesses, of being excited to action by stimuli, has been termed the principle of excitability. The author who first employed the term assumed it as an ultimate fact: and so far was he from endeavouring to explain the cause of that excitability, that he even deprecated the attempt*. This however has not deterred others from endeavouring to ascertain the cause or nature of that principle. The most remarkable attempt of this kind, is that lately made by Dr. Girtanner†. It is generally known, that

* Vide Element. Med. Brun. vol. i. p. 6.

† Vide Journal de Physique.

the leading principles of this gentleman's theory are borrowed from the writings of the late Dr Brown, although he has not acknowledged the source from which they were derived. To the theory of Brown, slightly modified, he has endeavoured to apply the discoveries of modern chemistry. By a variety of experiments, he has attempted to prove, that the excitability of the animal system, which he chooses to style irritability, is entirely owing to the presence of oxygene: or in other words, he asserts that oxygene is the principle of irritability. By the accumulation or exhaustion of this substance, he endeavours to explain the mode in which the various agents act upon the body. He has indeed almost solely applied his reasoning to the muscular fibre, which, in his opinion, becomes more or less irritable, in proportion to the quantity of oxygene contained in the system: in short, all the phenomena of life appear to depend upon the presence of this substance. Oxygene, then, with Girtanner, supplies the place of the vital

vital principle, the *archæus*, the animal soul, or the *vis medicatrix naturæ* of former theorists. The new theory has indeed this advantage over the old, that, instead of vague and unmeaning terms, we are presented with a substance with which we are in some degree acquainted, and which really exists in organized matter; so that the principle of life is here attributed to something.

We may readily admit that many of Dr Girtanner's experiments upon this subject are ingenious, and his reasoning frequently plausible; yet we cannot adopt his opinion: nor, in offering a sufficient refutation of it, will it be necessary to enter into a minute examination of his experiments, or the deductions which he has drawn from them. A few general observations will sufficiently evince that his theory is not tenable. I observe therefore, first, that oxygene is indeed known to be a constituent of animal bodies; and it may perhaps be received into the system in two ways: by respiration, and in the aliment. Before it is received into the body, and

assimilated to the system, in whatever form it is presented, it cannot be the principle of irritability, but is one of the agents which acts upon the excitable or irritable principle. After it is assimilated to the body, it forms only one of the constituents of which the organic matter consists; and it is undoubtedly the whole organic matter which is the subject of excitation, not merely one of its constituents.

But, secondly, if it is alledged that life, and consequently the capacity of being excited, is taken away from organized substances, by the with-holding the necessary supply of oxygene, it must be remembered, that the same effect is produced by with-holding any other of those agents which produce and support the phenomena of life; such as heat, aliment, &c. We might therefore as well suppose that the caloric, or matter of heat, the carbone, hydrogene, or azote, which we receive in our aliment; I say, we may as well suppose that one or more of these is the excitable principle, as oxygene.

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And lastly, were oxygene indeed the vital principle, the fact is not proved by those experiments which Dr Girtanner imagines the most completely satisfactory, or by the reasonings which he seems to think absolutely decisive. He has, with some propriety, attempted to form an arrangement of the different agents which act upon the body: he has divided them into three classes. The first he supposes to have the same degree of affinity to oxygene, or the irritable principle, as the organized fibre itself: these substances he therefore imagines produce no effect upon the fibre. The second class are those which have a less degree of affinity with oxygene than the fibre has; and which will therefore part with oxygene, and surcharge the fibre with it: these he supposes produce an accumulation of the irritable principle; and the substances which effect this, he calls negative stimuli. The third class contains those substances which have a greater affinity to oxygene than the fibre itself has, and which will consequently deprive

deprive it of oxygene, and produce the state of exhaustion: these substances he calls positive stimuli. To this arrangement several valid objections may be made; but I shall not enter upon the subject at present. What I am here principally concerned with, is the application which he makes of his experiments and reasonings on the two last classes, the negative and positive stimuli, in support of the opinion that oxygene is the irritable principle. He asserts that the positive stimuli, the most powerful of which he states to be alcohol, sulphuric æther, opium, and the oleum lauro-cerasi, deprive the fibre of oxygene, by actually entering into combination with it; and he supports this opinion by chemical facts, which are in themselves no doubt perfectly just, viz. that these substances are all highly combustible; i. e. that they have a great affinity with oxygene. But from these facts he draws a conclusion which is by no means admissible, viz. that they deprive the organized fibre of its irritability, by entering into combination
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with the oxygene it contains. When animal life is destroyed by any of the positive stimuli, he alleges, that the irritability of the moving fibre, in every part of the system, is instantaneously taken away. But allowing this to be the fact, it is impossible, at least in many instances, that it should have been effected by the actual combination of the positive stimulus, or combustible substance, with the whole, or the major part of the oxygene contained in the body. A single drop of the oleum lauro-cerasi received into the stomach, produces immediate death. But can the most credulous believe, either that the drop of oil was instantaneously changed into so minute a state of division, as to be distributed through every part of the system; or if it had, that it could attract and be united with the whole oxygene of the body? Will chemical experiment prove this? Quite the reverse. Let us subject such a portion of the oil to combustion, let us oxygenate it in the highest possible degree, and we shall find that the quantity of oxygene with which it will unite, will

will bear a very inconsiderable proportion to the quantity contained in the body of an animal, the life of which may be destroyed by a similar drop of the oil.

Upon the other hand, he supposes that the negative stimuli, as he terms them, communicate oxygene to the muscular fibre: among these he reckons many of the acids and oxydes of metals. The most powerful are consequently the oxygenated acids, and those metallic oxydes which most readily part with their oxygene. Thus the oxygenated muriatic acid; the oxygenated metallic salts, as the oxygenated muriate of mercury; and the oxydes of arsenic, mercury, and silver, he supposes, produce injurious effects in proportion to the quantity of oxygene they contain, and the facility with which they part with it. By communicating their oxygene, he supposes that the muscular fibre becomes hyper-oxygenated. But here, as in the former case of the positive stimuli, the cause is by no means adequate to the supposed effect. It is indeed true, that mercurial

curial and silver erodents destroy the organization of the part to which they are immediately applied, by their oxygene uniting with one or more of the constituents of the animal substance. But it cannot be admitted, that a few grains of the white oxyde of arsenic, or the oxygenated muriate of mercury, can possibly contain such a quantity of oxygene as will induce death by a hyper-oxygenation of the system. Dr Girtanner's opinion upon this subject is perhaps sufficiently refuted by a single fact, viz. that, according to his own supposition, we receive into the body, by a few inspirations, a greater quantity of oxygene than can be contained in the small portions of the mineral poisons we have mentioned which are sufficient to produce death. Why then is not the system hyper-oxygenated by respiration, as well as by these deleterious substances? It is in vain to reply, that the oxygene received by respiration, is only in such proportion as is immediately necessary to oxygenate the system. For the question here depends alone

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upon the quantity of oxygene received into the system in a given period : and it is evident that the quantity contained in such a portion of the oxyde of arsenic as will cause death, is exceedingly trifling. At any rate, a few inspirations of pure oxygenous gas ought, upon this principle, to be equally deleterious with a dose of arsenic.

By the term irritable principle, as we have already observed, Doctor Girtanner means that capacity which organized matter possesses of being acted upon by various agents. The observations which we have here offered, it is presumed, sufficiently prove, that in his attempt to detect the principle of irritability, he has not been more successful than his predecessors.

That the excitability of the body, and its various parts, depends upon a peculiar organization, seems perfectly clear; and perhaps a further knowledge of the subject is beyond the power of human research : yet we would not wish to be understood as precluding future inquiry. But we may be allowed to add, that forming uncertain

certain hypotheses upon this, or any other subject, cannot advance the interest of science.

Quitting then the vague opinions which have been held concerning the principle of animal life, we shall endeavour, by induction from the facts which pass under our observation, to ascertain the cause or causes which produce the phenomena of life, and maintain that life in the healthful state.

In the prosecution of this subject, we shall first take a brief view of the structure of the animal body, chiefly with the design of showing that a similar organization, under various modifications, takes place in every part.

Secondly, we shall endeavour to show, that by the union of the various parts of the animal body, a complete and indivisible whole is formed, so that any agent which operates upon a particular part, must in a greater or lesser degree affect the whole.

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Thirdly, we shall offer some general observations on the nature of excitability, or that principle, which appears to exist in every part of the body; and by which it is rendered susceptible of the action of various agents.

And lastly, we shall take a brief view of those agents, by the operation of which, upon organized matter, the phenomena of life are produced and continued.

In the course of our observations upon this subject, we must necessarily notice some of the causes that are injurious to health; and which, operating to a certain degree, destroy life. The agents which are necessary to produce the phenomena of life, and to preserve the healthful state, are naturally divided into two kinds; the external and internal. It is to this point alone, the production and continuance of life in the healthful state, that I mean to confine myself in this Essay: but it may be observed, that in taking an extensive view of this subject, it would be proper to consider

sider not only those which produce life and preserve health, but those which are directly injurious to the system; and also such as may be employed to counteract the effects of the injurious agents. This subject is exceedingly complicated; and it is difficult to form any accurate arrangement. The difficulty chiefly arises from the very different effects which are produced in the animal system, by the action of various proportions of almost any of the agents, which are capable of operating upon the body. Thus those agents, the operation of which is absolutely essential to life and health, will, when acting with too great force, induce disease, and even destroy life. The action of the same powers also, may be so modified, as to counteract the injurious effects produced by their own operation, or that of other agents. In like manner, some of those agents, the action of which is not essential to life, and which are able utterly to destroy the organization of the body, may, when employed in certain proportions, restore the system to the state
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of health. I shall attempt, however, to form an arrangement of these powers, although, from the intricate nature of the subject, I must necessarily expect that it may be liable to exceptions.

We may first mention those agents which, when acting in just proportion, produce the phenomena of life, and the healthful state. In treating on this class, it is necessary to consider the injurious effects which are produced by the same powers upon the organization, when acting in an improper proportion. We have observed, that they are naturally divided into the external and internal agents. The external agents, the action of which are essentially requisite to the production and continuance of the phenomena of life, are heat, air, and aliment. To these we may add, light, sound, and the qualities which we perceive in certain bodies, of odour and sapidity; which, though perhaps not absolutely essential to animal life, yet produce very powerful effects upon the system. Light is essential to the healthful
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state of almost every individual of the vegetable kingdom; and is perhaps, in the same view, requisite to the animal economy. Sound also produces very powerful effects upon the body. It is one of the most important agents in the intercourse of mankind. It is the chief mode of communication between the individuals of all the nobler species of the animal kingdom, and also affords a degree of intercourse between individuals of different species. The influence of sound upon the mental powers, produces in many cases, the most important effects upon the body. It is equally obvious, that the qualities of odour and sapidity, in certain substances, are capable of exciting the animal system in a high degree. The whole of these, therefore, may be properly considered as belonging to the division of external agents.

The internal agents, the operation of which are essential to the production and continuance of the phenomena of life, are, the

the blood, the fluids secreted from the blood, the intellectual functions, and muscular motion: to these we may add the sexual intercourse. This, though not essential to life, is a power which produces very considerable effects on the organization of almost every individual of the species. When confined within proper bounds, it is perhaps rather conducive to health, than injurious to the system; and should therefore be included in this division.

Several of these agents are intimately connected with peculiar functions of the body. It is necessary therefore, in treating upon the agents, to consider those functions in which their action is peculiarly evident. Thus, when treating upon air, we must necessarily consider the respiratory function; and the consideration of aliment should be combined with the digestive process.

The whole of this class, whether external or internal agents, evidently excite action.

action in the system at large, or more particularly in certain parts: it is plain therefore, that they possess stimulant powers; and we shall therefore appropriate to them the terms of the natural or healthful agents, or natural stimuli.

A second class of agents are such as are capable of operating, in various degrees, upon the body; the action of which, in any proportion, generally produces injurious effects, inducing the morbid state. The powers included in this class, operate in various degrees, according to their nature, the degree of their application, and the state of the body upon which they act. The mode of operation in different substances of this class, also vary exceedingly: some of them excite action in the system, whilst others instantaneously destroy life. We must conclude, therefore, that their qualities, and mode of operation, materially differ. In this class we comprehend the various species of contagion, as of the small pox, measles, chin-cough, typhus, the marsh miasmata, the

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venereal virus, the contagion of the plague, the azotic gas, and the various species of poisons, whether animal, vegetable, or mineral. It must be admitted, that very material varieties are observed in the operation of different powers in this list. The contagion of the small pox, for example, excites an increased action of the system; whilst that of the marth miasmata, or typhus, directly induces an universal and direct debility. No two powers can operate in a more opposite manner; nor can their action be accounted for, upon the same principle. It must be regretted, that the dispute relative to the stimulant and sedative effects of many substances, has degenerated into a mere logomachy, in which both parties were perfectly agreed as to facts, although they chose to dispute about words. Many of the substances which have been included in the list of sedantia, may be easily proved to be stimulants. But, on the contrary, it must be acknowledged, that the conclusion, that there is no direct sedative in nature,

nature, was too hastily drawn. We shall have an opportunity of illustrating this subject in some of the subsequent pages. As these agents differ in their qualities and mode of operation, we may apply to them the general term of morbid agents: or morbid stimuli and sedatives.

A third class of substances are those which are not natural or healthful agents, but which, when employed in just proportion, are able to counteract the effects of the morbid agents. Many of these may indeed be included in the list of morbid agents; and the whole of them, when acting in an undue proportion, will also produce injurious effects on the body. This list contains the whole of those substances, which can be employed as curative powers in the various diseases to which mankind are subjected. A considerable proportion of this class are undoubtedly stimulant: and probably the greater part are of the same nature. As distinctive appellations, we shall apply to

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them the terms, artificial agents, or artificial stimuli, and sedatives.

We proceed to take a cursory view of the structure of the animal body, chiefly with the design of showing, that a similar organization, under various modifications, takes place in every part.

In the human system we observe a variety of parts formed of matter apparently under very different kinds of modification. These, however, constitute a whole, the different parts of which are susceptible of various degrees of impressions from powers, to the action of which they are subjected. This entirely arises from the mode of their organization. The bones, from the nature of their organization, are perhaps less susceptible of the action of powers applied to them, than any other part of the system; they appear designed to form the basis of the body; they support the soft parts; they defend and contain the more delicate and noble organs. Though liable to disease, they are not subject to injury like the
other

other parts; and even after death, that rapid and spontaneous decomposition, does not take place in them, which we perceive in the rest of the system. They may be exposed for ages, without losing their original form; and they seem to bear a considerable analogy to inorganized matter.

Anatomical research, however, fully proves, that bone is as truly organized matter, as any other part of the body. This indeed is a conclusion which we might have drawn *a priori*, from the consideration, that inorganized matter could not possibly form a part of an animated system. The anatomist proves the truth of the assertion. He shows that the bones are supplied with blood vessels, as well as the fleshy parts. He exhibits their structure, and points out their periods of growth and decay, which can only be effected by the action of depositing and absorbing vessels; and in short, fully proves, that they are as truly organized matter as the rest of the body. But their organiza-
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tion is so constituted, as to be exactly fitted for the purpose they are destined to serve.

In fact, we observe, that bones are formed of a system of vessels, in the interstices of which, a seemingly earthy matter, mixed with mucus, is deposited. This earthy matter, which gives hardness and strength to the bones, is in reality in-organized and dead matter,—a true phosphate of lime, liable to no alteration when separated from the body, excepting by the operation of the laws of chemical attraction.

The bones are also supplied with nerves. They may be observed, in small threads, entering into the substance of the bones. Small nerves may also be seen entering into each bone, along with its nutritious vessels; and in some cases we observe them passing through large holes in bones, as the nerves which go into the jaws to supply the teeth. But, notwithstanding that anatomists can demonstrate the existence of nerves in the bones, yet the fact has

has been doubted, because the bones seem insensible to pain. It is true, the periosteum may be scraped from a bone,—a bone may be cut through, as in amputation, or in the operation of trepanning,—or caustics may be applied to bone; and the patient, in all these cases, scarcely feels any pain. It must, however, be admitted, that bone, even in the healthy state, possesses a low degree of sensibility. The actual cautery, which, in former periods, was much employed by surgeons, is known to produce a sensation in the bone, though said to be rather pleasant than painful. This, however, is a sufficient proof, that the bones are not absolutely incapable of feeling. But the sensibility of bone is sufficiently obvious in the diseased state: Injuries of various kinds will excite inflammation in it, as well as in the soft parts; and we observe the same phenomena produced in both. An increased determination of blood to the part swelling, a spongy looseness of texture, suppuration, and ulcer, take place in bone, in a manner

ner precisely similar to what we observe in the soft parts. And as in the latter the organization is destroyed, so also in the former we observe the bone eroded, and discharged by ulceration. During the progress of such a disease, the sensibility of the bone is astonishingly increased. Thus in the parts which possess the most acute feeling, we observe the sensibility increased by disease. In like manner the bones, ligaments, bursa, and other parts, in which, during health, the feeling is scarcely perceptible, become, by disease, extremely sensible, so as to give the most exquisite pain in many cases, superior to what is experienced in a similar disease of the soft parts.

In every view that we can take of the subject, bone appears to be as perfectly organized matter, as any other part of the body. It receives its share of the sanguiferous and absorbent vessels; it is supplied with nerves, and by all of them is immediately and intimately connected with the system at large. It is produced
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by the animalizing process ; it is liable to disease and death ; it is susceptible of impressions from stimuli ; and by their operation is excited to action.

Thus the bones are constructed upon a plan admirably calculated for the purpose they are intended to serve in the body. In order to give them hardness and inflexibility, they are chiefly composed of an earthy salt. This salt is deposited by circulating vessels, which enter their substance ; and when it has remained for a certain period, it is absorbed and carried out of the system by a set of vessels destined for that purpose. Thus a continual deposition and absorption is going on in the bones, as well as in any other part of the body. The nerves with which bone is supplied, are doubtless intended to supply the vessels which are ramified through its substance ; as we cannot suppose that they have any use with respect to the inorganic earthy salt, of which bone is chiefly formed. Upon the whole, then, it appears, that bone must be less capable

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of sensation, and less liable to be acted upon, than perhaps any other part of the body, as it is only the vessels and nerves which belong to it that are capable of sensation.

Cartilage possesses a degree of organization somewhat inferior to that of bone. This substance is interposed between bones, particularly at the joints, with the view, it would seem, of abating friction, and preventing those injuries which might be expected from the collision of the harder bony matter. Hence they are so constituted as to possess a degree of elasticity, by which they yield to the weight of the body, and are restored to their original size when that weight is removed.

Cartilage was at one time supposed to be a mere concrete, having little or no connection with the other parts of the system, except by mechanical cohesion. But, in the original formation of bone, it appears that cartilage is organized matter, and as truly connected with the system as any other part of the animal. Thus we observe,

observe, that the bone are terminated at their articulations by a thin cartilage; and the periosteum is extended over the surface of the cartilage. The circulation in cartilage is indeed not very active, but sufficient to preserve it in the living state. Had the powers of life been considerable in cartilaginous matter, had its feelings been acute, it must have produced very considerable inconveniencies to the animal: it would have been liable to frequent inflammation, and other disorders. But, having received a peculiar mode of organization, in which the feeling is obscure, and the excitability dull, it is admirably fitted to perform all the motions of the body, and is subjected to the friction of the joints, without being liable to injury.

The cellular substance, like bone and cartilage, possesses a low degree of sensation, and its excitability is obscure. This matter, under various modifications, is employed to unite, cover, and defend the other parts of the system. In all the forms

in which it subsists in the body, it possesses little sensibility; and may, when compared with the muscular and nervous solids, be almost considered as inanimate matter: that is, when in the healthy state, like bone and cartilage, its excitability is in a very low degree. Both mechanical and chemical stimulants, when applied to it, give but little sense of pain.

First, The cellular substance is extended over the whole body, and interposed between all the parts. Formed into an infinite multitude of cells, which contain fat and a thinner fluid, it is happily constructed to allow the parts to glide and move easily. It penetrates into the muscles, and keeps their fibres at a proper distance, so that the action of each may be duly exerted. It appears also to support and lubricate the muscular fibre, inasmuch that the strength of the system in health, and its weakness in disease, have been supposed in some degree to depend upon the proper or improper state of the cellular matter. It has generally been imagined, that the thinner
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fluid contained in the cells is designed to render the play of the fibres easy and free; and that the fat is intended to support the fibres in their action, to lubricate them, and to give a plumpness to the body. It has also been suggested, that it may be reabsorbed for various uses in the system. It is probable, however, that the sebaceous matter, like the phosphate of lime in the bones, can only be applied to its proper uses in the system for a certain period. By degrees it becomes unfit for the purposes of the animal economy. It is secreted and deposited in the cells, and, when reabsorbed, is probably, with other excrementitious matter, thrown out of the system.

Secondly, A modification of the cellular substance is employed as a covering to the bones. The periosteum, as it is called, appears to be a condensation of the cellular substance applied in successive layers, so as to produce a thick membrane, which conveys the blood-vessels, &c. to the bones.

Thirdly,

Thirdly, The tendons of the muscles are produced by a mere continuation of the periosteum, from which they are evidently derived, and not from the muscles, as the old anatomists imagined.

Fourthly, The tendinous matter somewhat differently modified, so as to form a thin membranous sheet, is employed to cover the muscles forming the vagina or fascia of the muscles. The cellular substance which lies under the fascia, and which immediately surrounds the muscle, appears to be only more loosely attached laminae of the fascia. It is from the fascia that the cellular matter is derived which penetrates into the muscles.

Fifthly, The periosteum, formed into a thicker membrane, and strengthened by the adhesion of surrounding parts, is employed for the capsules of the joints.

Sixthly, The bursae mucosae derive their origin from the same substance. The bursae are formed in those parts where a tendon plays over a bone. The upper surface of the bursa is formed by the tendon itself;

itself;—the lower surface of the same bursa is produced from the periosteum of the bone;—and the sides of the bursa are formed by the common cellular substance. The bursa mucosæ and capsular ligaments do not materially differ in their nature. They contain precisely the same kind of liquor, and they frequently communicate with each other*.

Thus, under a variety of modifications, the cellular substance is applied to many useful purposes in the system. It joins the bones to each other,—it unites the muscles to the bones,—it gives security and firmness to their motions,—by the fluids which it contains, it lubricates the joints and muscular fibre,—and it is further employed to give a plumpness and agreeable shape to the limbs.—For all these purposes it appears to be peculiarly fitted, by possessing a degree of sensibility much inferior to that of the more important parts of the system.

* Vid. Mr John Bell's Anatomy of the Bones, Muscles, and Joints.

Under all the modifications which we have now mentioned, cellular substance appears to have few blood-vessels, and no nerves; at least no nerves are visible. But we must conclude, that the few blood-vessels which convey nutrition to the cellular substance must be accompanied with nerves, however minute. And the feeling which can, by disease, be awakened in these parts, must lead us to infer, that they are in some degree supplied with nerves; as we cannot conceive that sensation can be produced, except by the agency of nerve. The paucity, however, of blood-vessels and nerves in the cellular substance, sufficiently evinces, that these parts can be little susceptible of the action of stimuli; and the fact which we thus discover from the structure of the parts, is strikingly evidenced by experiment. Under all its different modifications, cellular substance in the healthy state appears to be insensible to the action, both of mechanical and chemical stimulants. The tendons of animals have been cut and pierced

ced,—they have been pinched and torn,—the actual cautery, as well as the chemical, have been applied, without inducing the least indication of pain in the animal subjected to the experiment. The most violent chemical stimuli have been applied to the various parts of a joint, without producing any appearance of an uneasy sensation. In like manner, in chirurgical operations, the various modifications of the cellular substance may be operated upon without producing any degree of pain to the patient. Nay, it appears that little pain is induced by the accidental laceration of the ligaments and tendons. We cannot indeed say that these parts are entirely without feeling. Their sensibility is indeed dull. They receive the impressions of stimuli very slowly; but when, by disease, the organization of the part is deranged, the feeling is astonishingly increased, and the patient suffers a more acute pain than what we observe in almost any other part of the system. One thing, however, is obvious, the organ of sensation

tion in these parts must be precisely the same as in the rest of the body. It is only to the nerves that we can ascribe this quality. They may, in the cellular substance, during the state of health, be peculiarly sheathed and defended from impressions to which they become exposed when the organization of the part is injured by disease.

In the muscular and nervous fibre, we perceive the powers of life exerted with much greater activity than in those parts which we have hitherto noticed ; or, more properly speaking, muscular and nervous fibre are much more susceptible of the action of stimuli, than bone, cartilage, or cellular substance. It is by impressions upon these, by the operation of various agents, that every power of the body is awakened and called into action.

The muscular and nervous systems appear to be so intimately connected, that some physiologists have imagined that muscular fibre is a mere continuation of the nervous matter. Anatomy instantly refutes this opinion : The nerves enter into
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the muscles in every possible direction; and we may trace their branches and ramifications perfectly distinct from the muscular fibre. We cannot indeed trace their course to their termination, because they become deprived of their external coats, mere medullary matter remains, and disappears among the muscular fibres. It is perhaps still more clear, that muscular fibre is not a continuation of nerve, because muscles in the limbs of animals do not diminish in magnitude, although the nerves entering these muscles have been cut through for a considerable period. Yet there certainly exists an intimate and universal connection between the muscular fibre and the nerves; because neither the one nor the other can be acted upon by any stimulus, without the whole body being affected in a greater or lesser degree, according to the nature of the part, and the powers of the stimulus applied. We find then that both muscular and nervous fibre are susceptible of impressions from stimuli: But it is also

true, that the effects produced on these two substances in some respects vary. These differences will appear from the short account which we shall here give, beginning with muscular fibre.

Every distinct muscle is formed of a congeries of longitudinal fibres, which are connected together, as we have already hinted, by the cellular substance. They are extended from bone to bone, and from part to part, so as to form an almost universal covering to the bones, and are at the same time the instruments by which all the motions of the bones are performed. Each congeries of muscular fibre appears distinct from the rest, being terminated at its origin and insertion by its proper tendons, which, as we have said, are a modification of the cellular substance. Those muscles which are not inserted into any of the bones, as the sphincters and muscular membranes of the viscera and vessels, have commonly no tendons. Those, again, the origin and insertion of which are on different bones, and in the more moveable

moveable extremities, are generally supplied with long tendons, which pass round the joints and heads of the bones to be inserted in the more moveable part. But however distinct the different muscles appear, there is an universal connection, which depends upon the universal distribution of the nerves; one or more of which enter into each muscle, and thus form an indivisible whole.

The muscles are also abundantly supplied with arteries and veins, which enter within the cellular coat that surrounds the muscular fibres, and running in company with each other, are subdivided, and form a kind of reticular work. From the smaller of these vessels a vapour and fecaceous matter are secreted into the cellular substance, and which are again absorbed by lymphatics, the presence of which is also perfectly obvious, both on the surface and in the substance of the muscles. The ultimate fibres of the muscles appear to be small soft threads: When subjected to the microscope, they exhibit

exhibit a kind of wave or zigzag appearance. This form has been attributed to the impressions made by the vessels, cellular substance, and nerves upon the fibre. The learned Professor of Anatomy in this University has however demonstrated a similar appearance in the tendons and nerves; and he is of opinion, that these undulations are a kind of folds or joints, which serve to accommodate the parts to the different states of flexion and extension. In proof of this, he observes, that these appearances are only present when the parts are in a relaxed state, and that they entirely lose it when much stretched.

Many opinions have been entertained with respect to the structure of the muscular fibre: It has been supposed that they are solid; again it is said that they are hollow, being formed of a series of vessels or rhomboidal chains communicating with each other; and lastly, it has been alledged, that they are full of a kind of down or woolly substance. The fact cannot be determined by the eye or the microscope,

croscope, and therefore I conceive it not worth while to engage in the dispute. Indeed, as far as we can discover, the muscular fibre, when washed from the blood contained in the vessels which accompany it, appears a white soft solid.

These delicate fibres, formed into bundles of different magnitudes, and variously disposed,—supplied with blood-vessels and absorbents,—joined together, and supported by cellular substance,—and united together, so as to form one grand system, by the distribution of nerves, are destined to perform the most important offices in the body. Every motion is produced by their operation. They possess a kind of contractile power, by which they are fitted to propel the blood from the heart, and direct its course through all the numberless channels in which it flows throughout the body. They produce the action of the lymphatics, by which absorption is carried on;—by their energy, every secretion and excretion of the system is performed;—the important function

tion of respiration depends upon their exertion ;—and they effect the various motions of the body, which are of so much utility in the different avocations of life. To render them capable of producing these effects, they are in a high degree endowed with that susceptibility of the action of stimuli, upon which the commencement and continuance of life depends.

We are next to direct our attention more particularly towards the Nervous System.

The brain, or that mass which fills the cavity of the cranium, is at once the origin and point of union to the whole nervous system. This general mass is divided into three particular portions,—the cerebrum,—the cerebellum,—and the medulla oblongata; and a continuation of the latter forms the medulla spinalis, which fills the cavity of the vertebræ. This organ, and the various branches derived from it, form one of the most important parts of the animal œconomy. It

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is essential to all the nobler species of animals ; but its importance is more peculiarly evident in man than in any other. In the human race, it bears a much larger proportion to the size of the animal than in any of the inferior orders. The nerves, which form the various organs of sensation, and upon which ultimately the action of muscular fibre depends, are derived from the brain in the inferior animals, as well as in man ; but, from the much larger size of this organ in the latter, it appears destined to perform some other and more important purposes in him than in the former. The whole of the nerves, it has been observed, bear but a small proportion to the mass of medullary substance contained in the brain, being at least an hundred times as large as the diameters of all the nerves of the head and spinal marrow. It does not appear that the large size of the brain gives to man more acute sensations, or a greater power to produce muscular motion, than other animals possess, in which the brain is proportionally

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much less. Thus, as Dr Monro has observed, the brain of a large ox has been found to weigh not more than one fourth part of the human brain, whilst the weight of the ox was probably six times greater than that of the man; or the brain of the man was, in proportion to his weight, twenty-four times heavier than that of the ox. At the same time, the nerves of the muscles of an ox are in their size proportioned to the bulk of the animal's muscles, and those of the organs of sensation, as the eye and nose, are proportioned to the extent of these organs. Thus the olfactory nerve of an ox is many times larger than that of a man. Again we observe, that three fourths of the nerves originate from the medulla spinalis; yet it is only a small part of the brain which is elongated, and passes down the vertebral canal. We have reason therefore to conclude, that to give origin to the nerves is not the sole use of the brain: it is the seat of intellect; the medium
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by which impressions made on the organs of sensation are conveyed to mind.

The whole of the nerves, then, arise from one common source; and the brain must be considered as the central point at which they all unite. Arising from this point, they are transmitted to every part of the body,—they are interwoven in every organ of sensation,—every muscle, vessel, and bone, and thus unite the various parts so as to constitute an uniform system. Possessed of a peculiar organization, by which they are highly susceptible of impressions from various stimuli, they receive impressions on every part, which appear to be instantaneously transmitted to the central point, the *cenforium commune*. Hence it is, that the action of a stimulant upon a particular part does not affect that part only to which it is applied, but operates in a greater or lesser degree upon the whole system. Minute anatomy evidences, by an infinite variety of circumstances, the peculiar fitness of the brain and nervous system for produ-

cing these effects. We must not here enter into a particular description of the anatomy of these parts; but we shall endeavour to illustrate the subject by a few general observations on the structure of the brain and nerves, and the distribution of the latter through every part of the body.

We have observed, that the brain is formed of three portions, the cerebrum, cerebellum, and medulla oblongata, to which a fourth may be added, the medulla spinalis. The whole of these are covered by their peculiar membranes, the pia mater and dura mater. These serve for their protection, and to convey blood-vessels for their nourishment and support. The brain is supplied with numerous blood-vessels from the carotid and vertebral arteries; and by the many convolutions which they make before they pass through the dura mater, and the vast number of communicating branches into which they are divided in the pia mater, and its processes, it appears, that the blood must

must move more slowly and equally in those vessels than in those of other parts. We may also add, that the arteries in other parts are in some degree acted upon by the labouring muscles, and the pressure of the atmosphere, by which the blood is propelled with additional force. But the arteries which supply the brain, after they enter the cranium, are not subjected to the operation of these powers. We observe then, in this distribution of the blood-vessels of the brain, a provision made against those injuries which must have infallibly taken place in so delicate an organ, if it had been possible for the blood to have been driven into it with great violence. A very considerable quantity of blood is transmitted to the brain,—it is derived from trunks which arise near the heart;—and, according to the opinion of Haller, a sixth part, or, as Dr Monro supposes, not less than a tenth part of the circulating mass, is transmitted to the brain. From the ample supply of this fluid which the brain receives, it appears

appears that perpetual and important changes take place in the substance of the brain and nerves, as well as in other parts.

The cerebrum, cerebellum, and spinal marrow, are naturally divided into the external part, the cortex or cineritious substance, and the internal part, or medullary matter. The minute branches of the blood-vessels, by the assistance of injections and the microscope, are found to pass from the pia mater into the cortical part in vast numbers; in fact, it appears to be almost wholly formed of vessels; but into the medullary substance we only observe longitudinal vessels entering. The veins which return the blood from the brain are of a peculiar structure, evidently designed to facilitate that return. Their coats are of peculiar strength: they form innumerable anastomoses with one another; and when collected so as to form considerable trunks, they are lodged in canals, which prevent them from being subjected to compression. A provision therefore is evidently made to prevent an injurious

rious accumulation of the blood in this organ. It has been doubted, whether the brain is supplied with lymphatics? They may certainly be demonstrated upon the pia mater; and from analogy drawn from every other part of the body, we can scarcely suppose that the brain is destitute of lymphatics. Indeed modern physiologists in general admit the existence of lymphatics in the brain.

From the blood-vessels, as we have already hinted, the cortical part of the brain receives its origin. Anatomical injections fully prove, that the greater part of it consists of vessels which are inserted from the small branches of the pia mater. These vessels, however, in the natural state, do not convey red blood, but a thinner fluid; although in some diseases, and in death by strangling, particularly in brutes and birds, the red blood is propelled into them. No anatomist has, indeed, succeeded in filling every portion of the cortex with injected matter; yet it is probable, that it is altogether vascular. We observe no dissimilarity

larity of parts in it when in the entire or natural state, so that we cannot imagine that it is partly vascular and partly solid.

As the cortical substance originates from the vessels of the pia mater, so the white medullary matter is derived from the cortex. The continuity of the medulla with the cortex, is distinctly seen by the microscope, and may even be observed by the naked eye. Minute portions of the medulla may be observed proceeding from the cortex; and its gradual increase may be traced, becoming more broad and abundant till it makes up the whole oval section of the brain, and is bounded only by the convolutions of the cortex.

The medulla is extremely soft, and of a fibrous texture. The fibres are visible in several parts of the human brain, and still more evidently in the brains of fishes, especially in their thalami optici. The fibres of the medullary substance are simply extended, so as to form the white fibrous cords which are distributed to every part of the body, and which are universally

fally termed the nerves. That the fibres of the nerves are merely a continuation of those of the medulla, is distinctly seen in the seventh, fourth, and fifth pairs of nerves.

The nerves, then, are composed of many fibrous threads, lying parallel, or nearly so, to each other, as they shoot off from the medulla. At the origin of most of the nerves within the skull, this fibrous texture is perceptible: and in the cauda equina of the spinal marrow, they may be divided into threads, so exceedingly minute, that they are scarcely visible to the naked eye: yet even these fibres, when examined with a microscope, appear to be formed of a considerable number of fibrils, much more minute.

It is perhaps not possible to estimate the size of the smallest of these fibres. Were the nerves, which are divided over the whole body, conjoined into a cord, the diameter would not be an inch; yet even the most minute part of the body is sensible: and this must depend on each particular

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point being supplied with nerve. We must therefore be convinced, that the nervous fibrils are astonishingly small. Nay, it has been demonstrated, from the extreme minute portions of matter which are visible to the sight, that each fibre in the retina of the eye cannot exceed in diameter the thirty-two thousand four hundredth part of a hair.

The medullary matter, of which the nervous fibrils are formed, is exceedingly delicate and soft. They are therefore connected together by cellular substance, and protected from injury by coats formed of the dura and pia mater. These nervous cords are so liberally supplied with blood-vessels, that when their arteries only are injected, the whole cord appears to be tinged with the colour of the injected liquor.

The nerves, after being given out by the brain or spinal marrow, are generally, like the blood-vessels, divided into branches: but they pass off, or separate, from each other in acute angles, and often in a retrograde

retrograde direction. The fibrils of the nerves, however, are not split at these divisions so as to form smaller threads; but the original fibres, continued from the brain itself, recede from each other by an opening of the cellular substance by which they are united: so that, after the nervous fibril has left the brain, it appears, in fact, to undergo no change till its ultimate termination. The nervous cords generally appear to grow softer during their course, till at length, at their termination, they seem to be lost in a mucus or pulp. Hence it has been supposed, that during their progress they deposit the coats which they had received from the pia and dura mater; and that, to be capable of sensation, or the other purposes which the nerve is to effect in the system, it is necessary that the medullary part should be laid perfectly bare at its termination. It is, however, alledged by Dr Monro, that every filament of a nerve retains, at its termination, a covering of the pia mater, by the vessels of

which it is nourished and preserved in that state, upon which the faculty of receiving impressions, and the power of action, depend.

In some instances we observe different nerves uniting so as to form one cord; this, in some measure, resembles the inoculations which take place in the sanguiferous system. After such an union, we frequently find, particularly in those which are distributed to the bowels, a hard knot is formed, considerably larger than the nerves which are thus united into a cord. These knots are generally termed ganglions: They have thicker coats, and are more liberally supplied with blood-vessels than the nerves. Dr Monro observes, that they are full of nervous fibrilli, intermixed with a yellowish or reddish brown substance, somewhat similar to the cortical substance of the brain. Hence he supposes, that they are sources of nervous matter or energy.

Derived from this origin, (the brain), we find forty pairs of nerves distributed through

through the body, viz. ten which immediately proceed from the encephalon, and thirty which pass off from the medulla spinalis. Of these we find four proceeding immediately from the brain, which are destined to receive various impressions from external objects, by which the sensations of sight, hearing, smell, and taste are produced. The rest are distributed to the various muscles, and extended on the surface of the body, effecting the motion of the muscular solid, and producing, in every part of the system, by impressions from different substances, that sensation which we call feeling. To whatever purpose the nerve is applied, whether to receive sensation, or to excite motion, we do not perceive any difference in its structure; it is in every instance formed of the same soft medullary fibre. We perceive, indeed, the optic nerve, at its termination, is extended into a delicate web, which covers the surface of the eye. The *portio mollis* also of the auditory nerve, is extended in a very soft pulpy form on the inner

inner camera of the ear ; but, excepting these two, we observe no variations in the external appearance of the nerves at their terminations : Nor do we discover, even in these, any peculiarities of structure, by which we can be able to assign a reason why the one should receive the rays of light, reflected from surrounding bodies, by which the sensation of sight is produced ; or why the other should be affected by percussions of the air, so as to communicate the different sensations of sound. We observe, indeed, that several of the nerves which are designed to communicate particular sensations to the mind, are furnished with peculiar apparatus. Such, we observe in the wonderful structure of the eye ; and in the striking contrivance exhibited in the vestibule, cochlea, and semicircular canals of the ear. That these apparatus are essentially requisite to enable the nervous matter to receive particular sensations, cannot be doubted : But it must remain as a question which probably will never be determined, whether the medullary matter

ter itself does not undergo some modification, by which it is fitted respectively to receive impressions from light, sound, odorous or sapid substances;—to distinguish the nature of other substances by what we call feeling,—or to excite the muscular action. Whatever may be in this, we are certain, that sensation altogether, and muscular motion in a great measure, are produced by the operation of various agents upon the nervous system. If a nerve is irritated, acute pain is induced; and in proportion to the number of nerves with which any part of the body is supplied, it is possessed of a greater or lesser sensibility. Thus, in the eye and the penis, which are plentifully supplied with nerves, the feeling is extremely acute; and the tendons, ligaments, bones, and cartilages, into which few nerves enter, have in the sound state little or no sensation. But if, on the other hand, the communication between the sentient extremities of the nerves and the sensorium commune is obstructed, as by the division
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of the nerve, the sensation of the part beyond the division is entirely destroyed.

Having thus taken a cursory view of the various parts of which the body is composed, and having briefly pointed out the respective uses of each, we proceed, secondly, to show, that by the union of the various parts of the animal body, a complete and indivisible whole is formed, so that any agent which operates upon a particular part, must in a greater or lesser degree affect the whole.

By the union of the various parts of the animal body, an indivisible organic system is constituted. While this organization subsists, and the proper powers act upon it, life continues; and the living principle is precisely the same, one and undivided, in every part of the system. This unity, as we have already said, is effected by the universal distribution of the nerves to every part of the body. It is impossible to account for the effects produced by the action of all or any one of these powers, which are capable of operating upon the
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body, excepting from this fact, that it forms an indivisible whole. As this is a point of considerable importance in physiology and the practice of medicine, it is proper to illustrate it, by mentioning a few facts, which fully prove that no power can operate upon any part of the body without producing similar effects in a greater or lesser degree throughout its whole substance. And first, If a stimulus is applied to any part of the system, the whole is, in a certain period, brought into the same state as the part to which the stimulus was directly applied. The action of the stimulus is indeed first exerted on the organization of the part to which it is immediately applied; and if it is of that class of stimuli which produces a temporary energy in the system, as alcohol or opium, we find that vigour is induced, or the action of the system is first excited in that part to which the application of the stimulus is made; but in a short period the same energy is produced throughout the system. On the contrary,

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if any power which is capable of producing a debilitating effect is applied to a particular part, debility is immediately produced in that part; but it will quickly be extended in a certain degree over the whole. It is true, every part of the body is not equally susceptible of the action of stimuli. The brain and the alimentary canal, for example, are more powerfully acted upon by a given stimulus than the surface of the body. But this does not arise from any essential difference in the organization of these various parts, by which the former are susceptible of the action of the stimulant, and the latter not; for they are all capable of receiving a similar impression, though differing in degree. It arises then merely from the organization on the superficies of the body being so modified as to render it less susceptible of the action of stimuli than the brain or stomach. The same reasoning applies to all the varieties which we observe in the action of different powers, whether

whether the healthful or the morbid, upon various parts of the body.

The unity of the system is again sufficiently proved by the effects produced by a debilitating power being applied to any part of the body. We observe these effects most strikingly in persons whose organization is delicate and feeble. In these the application of such debilitating powers will produce *deliquium animi*. Thus certain odours will induce this effect. A blow on, or strong compression of the points of the fingers, will also induce *deliquium animi*. In some instances, the continued operation of these powers, and perhaps in all, if the degree of their action is somewhat increased, life will be destroyed. Upon the other hand, if the vital functions have not been too long suspended, the application of a gentle stimulus to any part of the body, will reproduce the exercise of these functions. This sympathy, which we observe in all these cases between the various parts of the body, cannot be accounted for except we admit,

that throughout the system there is a sameness of structure, and universal unity of substance; so that if any part be affected, the whole system must more or less suffer, in proportion to the degree in which the injurious power operates.

The indivisibility of the body is farther proved, by the phenomena of various diseases. Thus vomiting is frequently produced by the presence of biliary concretions in the gall ducts, or by calculi in the kidneys, ureters, or bladder of urine. This sympathy, subsisting between the stomach and the part to which the irritating substance is applied, can only be explained upon the principles which we have just stated.—So also injuries received by the head, frequently produce vomiting, and spasms of the muscles in the opposite side of the body to that upon which the injury was applied; which strictly proves, that the brain is an indivisible mass, and that all the nerves are merely a continuation of it.—Spasmodic affections also; of many of the voluntary muscles, often

often occur during severe vomiting, and purging.—In like manner, a wound in any of the extremities, and even in the most distant part of an extremity, will produce a locked jaw. The whole of these effects can only be accounted for, on the supposition, that by the universal distribution of the medullary fibre, every part of the body is united, so as to constitute an indivisible whole.

This subject may be farther illustrated, by the effects produced on the body by the operation of the more powerful articles of the *Materia Medica*. A large doze of opium taken into the stomach, will entirely destroy sensibility in every part, and quickly produce death; and the same substance, when employed in a proper quantity, will procure an abatement of pain in the most distant parts, and will remove a spasmodic affection of all or any muscle of the body.—It may be added, that a given quantity of opium, injected into the rectum, will not produce the same effect in relieving painful sensations,

tions, or in removing spasm, as if it had been received into the stomach. We have already assigned the cause:—The organization of the rectum does not essentially differ from that of the stomach, but, from its peculiar modification, it is not so susceptible of the action of stimuli as the internal surface of the stomach. But a sufficiently large dose of opium injected into the rectum, would as infallibly destroy life, as a smaller when received into the stomach. Nor are the deleterious effects of opium, or any other substance, produced by these matters being applied to every part of the system, but merely by their action upon any part of the organized matter. It was indeed at one time a generally received opinion, that no article whatever could produce death, unless it entered the general mass of circulating fluids, and was by that means conveyed to every part of the body, or at least to the nobler parts. But we have the most demonstrative evidence, that these deleterious effects are produced without

without a particle of the poisonous matter being mixed with the circulating fluids. Thus, if the sciatic nerve of a frog is laid bare, and a solution of opium is applied, the life of the animal is immediately destroyed.—Now, if the same experiment is performed upon a frog, the heart of which has been previously cut out, so that the circulation is entirely interrupted, the same effect will be produced. This experiment affords a clear proof that the poison was not conveyed by the circulating fluids. We have also formerly noticed, that instantaneous death is produced in the strongest man by a single drop of the *oleum lauro-cerasi* being received into the stomach; and in this case, neither the quantity of matter received, nor the period required to produce death, will permit the supposition, either that the poison has been received into, or that it is transmitted by the circulating fluids. We must be satisfied that the poison acts upon that part of the organized substance with which it is immediately

mediately in contact, and that its effects are transmitted with such astonishing celerity through every part of the system, because that system is perfectly indivisible.

The influence of the mental energy upon all the voluntary muscles, affords another clear proof of the indivisibility of the body. The determination of the mind to perform a particular action, is frequently instantaneous; and no sensible point of time intervenes between the mental determination, and the muscular motion by which the action is performed. In some instances, the effect so instantaneously accompanies the determination of the will, that we are almost ready to ascribe it to a mechanical operation, rather than to mental volition. Thus, the motion of the limbs in dancing, is so perfectly synchronous with the sound of the music, that we can scarcely observe any exertion of the mental faculty. Yet in this case we easily perceive that the sound must have acted upon the auditory nerve,

nerve, — the sensation must have been transmitted to the sensorium commune, — and the determination of the will, in consequence of this sensation, must, in the order of things, have preceded the muscular motion. In the order of time, however, we cannot, by the most accurate examination, perceive that the sound of the music precedes, in the least degree, the last effect produced, viz. the motion of the limbs. Can we possibly account for the instantaneous effect produced on the bodily organs by the mental decision, except on the principles here stated?

As a last and equally decisive proof of the indivisibility of the body, we may mention that relation which subsists between it and the passions of the mind. Agreeable passions, or the passions restrained within moderate bounds, produce the same beneficial effects upon the body as the other healthful or natural stimuli. But when these are excited to a considerable degree, so as to produce, for example, excessive joy or extreme grief, we find

that their effects are as injurious to the body as the most powerful external agents, producing various effects, as debility, mania, and even death, in proportion to their nature, and the degree of their action; on the contrary, if the organization of the body is considerably affected, a mental imbecility, or a total derangement of the mental functions, not unfrequently follow. These facts sufficiently show the intimate connection which subsists between the mental functions and the bodily organization; and afford no indecisive proof, that the organized matter of animal bodies must be considered as forming an indivisible system. And, as we have already said, while this organization continues, and the proper powers act upon it, life continues, and the living principle is precisely the same, and undivided in every part of the system.

The human body then, although made up of parts that are seemingly dissimilar, particularly with regard to structure, appears

pears to be a complete whole ; and each of these parts, from the peculiar modification of its organization, is admirably fitted for performing the purpose to which it is destined. The bones, cartilages, and the cellular substance, are less susceptible of the action of stimuli than the muscular and nervous fibre. These last form the most important parts of the body, and upon them the action of every power is most eminently exerted. At the same time, no agent can operate upon any part of the body, whatever may be the peculiar modification of organization in that part, without the whole being ultimately affected.

We go on, thirdly, to offer some general observations on the nature of excitability ; or that principle which appears to exist in every part of the body, and by which it is rendered susceptible of the action of various agents.

The subject of animal life is a simple uniform organized body. But, as we have said, no mode of organization whatever

is sufficient to produce the phenomena of life, unless certain peculiar agents operate upon this organization: and these agents must be accommodated, both in their quality, and in the degree of their operation, to the peculiar structure of the organized substance. Thus life is produced and continued by the healthful or natural stimuli acting in due proportion. By totally abstracting all or any of these stimuli, or by their acting in too great a degree, the functions of life are impaired, and at length totally destroyed. By the action of any of the morbid stimuli, health is injured; and when they operate to a certain extent, the powers of life are entirely extinguished. Again, when injurious effects have been induced by the abstraction or too forcible operation of the natural stimuli, or by the action of the morbid stimuli; these injurious effects may be obviated, and the health of the system restored, by employing the artificial stimuli in due proportion. These facts fully prove that the phenomena of life are produced by

by the operation of certain agents upon organized matter. The phenomena, from the presence of which we can infer the existence of animation or life, are, in the inferior orders of animals, sensation and motion. In man, we may add to these, the exercise of the mental functions. Yet if none of these are present, we cannot absolutely conclude that life is extinguished, while no material alteration has taken place in the bodily organization. Daily observation furnishes us with many facts that prove the possibility of producing the phenomena of life, after they have been suspended for a longer or shorter period. But the same facts also furnish the most decisive evidence that this reproduction of life is solely effected by the action of stimuli upon the bodily organization. In the partial and very temporary suspension of the vital functions during *deliquium animi*, we see an example of the organization being so far injured, as not to be susceptible of the action of the ordinary healthful stimuli. In these cases, the reproduction

reproduction of all the vital functions is at least facilitated by employing some of the more powerful of the artificial stimuli. Again, in that suspension of the vital functions, for a longer or shorter period, produced by submerision, we observe the phenomena of life to disappear, simply by the abstraction of the stimulus of air. This is one of the natural stimuli, the perpetual action of which (on principles which we are shortly to explain), is necessary for the continuance of life. This stimulus may be abstracted for a certain time, without the organization undergoing any material alteration. When the body is taken out of the water, it is indeed incapable of being acted upon by the ordinary healthful stimuli: and if the artificial stimuli, in various modes, are not employed, the different animal functions will no more be called into action. In this case, the reproduction of the phenomena of life, evidently depends upon the action of stimuli. It deserves here to be remarked, that one of the most important of these is the artificial

artificial introduction of one of the natural stimuli, viz. air, into the lungs. Perhaps the most important agent in these cases, in restoring the tone of the fibre, so as to render it capable of being acted upon by the healthful stimuli, is heat. Animal heat is chiefly, if not wholly, supplied by the respiratory function; and if respiration has been too long obstructed by submerſion, or, in other words, if the stimulus of heat has been too long abstracted from the animal body; we find the organization is so much deranged, that it is no longer susceptible of the action of the most powerful stimuli, whether natural or artificial; and the powers of life are for ever extinguished.

That the production of the phenomena of life depends upon the action of stimuli upon the bodily organization, may be further illustrated, by many experiments which have been made upon organized matter, even after the functions of life have ceased. Thus we find that the muscular fibre, even when separated from the system,

system, may be excited to action, by mechanical and chemical stimuli, for a considerable length of time after the apparent death of the animal, or after the separation from the system of the particular portion of muscular fibre upon which the experiment is performed. It was indeed formerly supposed, that this property of being excited to action after apparent death, was confined to the muscular or irritable fibre: but the influence recently discovered by Galvani, clearly shows that the medullary fibre also is susceptible of the action of stimuli after the functions of life have apparently ceased. In the experiments upon animal electricity, as it has been improperly called, it is sufficiently plain, that two or more metals, when brought into contact, are capable of producing a peculiar and powerfully stimulating effect upon the organs of sensation and motion, whether in the perfectly living state, or after apparent death. But even these metallic stimuli, however powerful, cease to excite either the medullary

lary or muscular fibre, when the organization has undergone a certain degree of derangement.

It may be further observed, in proof of this doctrine, that the susceptibility of the animal fibre for the action of stimuli, after the phenomena of life have ceased, is extremely varied in different subjects. The degree of its susceptibility depends upon the greater or lesser degree of derangement in the organization produced by the immediate cause of death. For example, the fibre of a person whose life has been destroyed by certain species of poison, is much less capable of being excited by stimuli, than that of a person dying by several ordinary diseases, or of one whose life may have been suddenly taken away, in a state of health, by strangling, or other modes by which the organization has not undergone any material injury *. These varieties in the

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* Dr Girtanner has attributed, as we have already noticed, these variations in the excitability or irritability

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state of the animal fibre in different subjects, after the cessation of the ordinary phenomena of life, cannot be accounted for, excepting on the supposition that the organization has undergone different degrees of derangement by the various causes of death.

During the continuance of life, we frequently see the state of the fibre extremely varied, with respect to its susceptibility of the action of stimuli, by different diseases. Paralysis affords a very striking illustration of this observation. We see a person apparently enjoying the fullest state of health,—the vital functions seemingly in

ty of the muscular fibre, to the abstraction or addition of oxygene. This opinion is merely hypothetical. Oxygene may indeed be extracted from the muscular fibre after death; and it would perhaps be worth while to try the experiment, whether as much oxygene may not be obtained from the muscular fibre of an animal, the life of which has been destroyed by one of the Doctor's positive stimuli, as from an equal quantity of the muscular fibre of another animal, the life of which has been taken away by one of his negative stimuli. I suspect such an experiment would entirely overthrow Dr Girtanner's theory.

in the most perfect exercise,—and all the life-supporting powers acting upon him with their usual force,—when suddenly, some of his muscles lose the power of motion. To what cause are we to ascribe this change? Certainly to a change in the organization of the part, by which it is rendered incapable of being acted upon by the natural stimuli. How are we to remove the disease?—If it is remediable, every one will admit, that the effect can only be produced by employing the natural and artificial stimuli in due proportion.

In every view that we can take of this subject, it appears then, that the phenomena of life can only be produced in bodies peculiarly organized; and that these phenomena commence, and are continued, by the operation of certain agents, the action of which must bear a fixed proportion to the state of the organization. Upon these simple principles we account for animation; and the theory we find supported by all the phenomena of nature

which pass under our observation, and by all the experiments which we can perform upon organized substances. In vain then shall we search for any principle of life, excepting the action of these agents upon matter which, by its peculiar structure, is susceptible of their operation. The suspension of respiration, and the cessation of the action of the heart, have, by some, been supposed the cause of death: But in fact these vital functions never cease, unless the powers which, by their stimulus, excite their action, have been abstracted, or that the organization has suffered such a derangement as to render the body unsuceptible of the action of these powers. In either case, the cessation of action in the heart and lungs is merely an effect, not a cause of death: and that effect is either simply a consequence of a faulty action of the life-supporting powers, or a derangement of the bodily organization.

From the facts here adduced we may warrantably conclude, that it is only by
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the various modifications to which the animal fibre is liable, that we can explain all the phenomena of health and disease. It is by the different states of the organization that the various stages of animal life are formed, as infancy, childhood, youth, manhood, and old age. The various modifications which take place in the fibre during these periods, render the operation of stimuli upon the body exceedingly different. At the same time we shall find, that these different modifications of the organization are, in a great measure, produced by the continued operation of the healthful or natural stimuli upon the body.

The susceptibility which we observe in animal bodies, of being acted upon, and excited to action, by various agents, has been termed excitability. The powers which produce this effect are consequently named exciting powers; and the effect produced by their action is styled excitement, or the state of excitement.

Excitability is then a property inherent
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in living matter. We have ascribed it to a peculiar organization ; and the varieties which we observe in the phenomena of life, as they appear in different orders of animals and vegetables, we also refer to the different modifications of that organization. That excitability peculiarly belongs to organized matter, is a fact, for the truth of which we have ocular demonstration ; and it is an ultimate fact, beyond which it seems impossible for human research to be extended.

It will from hence follow, that the state of the organization will, in all cases, express the state of the excitability. The latter will always vary according to the different modifications which the former undergoes ; or, in other words, the state of the organization and the state of excitability are convertible terms.

To illustrate this subject, we shall endeavour to consider the principle of excitability, or the state of the animal organization, in several points of view ; and first, as it appears in an individual at the three different

different periods of life, infancy, manhood, and old age.

Infancy is distinguished by a weak and delicate organization : the weakest stimulus, and in the smallest quantity, is capable of exciting action in the system ; and hence nature has provided, in the mother's milk, a mild nutritious fluid for its support. The weak state of the animal fibre, renders it impossible to produce in the infant system vigour of body, or that state which has been termed high excitement. Hence the susceptibility of being excited by different agents, whether natural or artificial, is, by their too powerful operation, quickly destroyed. A full meal of the mother's milk, or other mild substances, soon induces sleep ; and a very small dose of the stronger stimuli, as alcohol or opium, will immediately destroy life, or utterly exhaust the excitable principle. These facts lead to a plain conclusion, that a high state of excitability implies a feeble organization. It follows also, that the operation of those agents which

which produce action in the system, eventually destroys its capacity for being excited. Too great a quantity of the most proper food soon produces debility in the infant fibre; and, as we have just said, the more powerful stimulants, in a very minute proportion, will quickly so much derange the organization, as to render it incapable of being excited.

In some of the succeeding pages, we shall have occasion particularly to show, that many of those agents, the operation of which is necessary to the production and continuance of life, do not act merely as simple stimulants, but that, by the addition of new matter, they communicate vigour to the body, and hence preserve the animal existence. Such is the use of aliment in general. The infant fibre is so modified, as to be capable, by the action of the healthful agents in just proportion, particularly aliment, to receive an accession of new matter, to increase in size, and to acquire a more vigorous organization. Hence the body becomes less susceptible
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of the action of stimuli: it requires a greater proportion of these agents to produce the usual effect; or, in other words, the excitability is diminished, and the system becomes capable of a higher degree of excitement.

As the too powerful action of stimuli, whether natural or artificial, quickly deranges the infant organization, or exhausts the excitability, so also that principle is rapidly accumulated by the abstraction of the healthful agents. From the feeble state of the animal fibre in this period of life, it follows, that any abstraction of the usual necessary stimuli will induce weakness in the organization; and if this abstraction is carried to a certain extent, life is destroyed.

Here it must be remarked, that we do not perceive any very material difference in the effects produced on the animal body by these two seemingly opposite causes, the too powerful action, or the total abstraction of stimuli. It is obvious, that each of these causes produces debility: The effect of the first has been termed
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indirect, and that of the second, direct debility. Perhaps it is proper that some distinctive terms should be employed to denote the effects of causes so different, although ultimately their effects appear to be precisely the same. We shall have occasion again to advert to this point, and shall therefore only observe at present, in illustration of the subject, first, that the operation of stimuli must be various, in proportion to the degree of their action. When employed in a moderate degree, or just proportion, they do certainly exhaust the excitability, or render the system less susceptible of their action. But in this case that susceptibility is quickly restored, and brought to the healthful point, by rest, and the accession of new matter from the aliment. If, again, stimuli are employed in too great, though not in extreme proportion, the susceptibility of excitation is still more rapidly, and to a greater degree, diminished; but no sooner has the operation of the stimuli completely ceased, than we perceive a considerable

considerable degree of weakness induced, attended with a high degree of excitability. But if the operation of the stimuli is in the extreme, the excitability is totally destroyed, i. e. the powers of life are annihilated. Secondly, by the abstraction of the usual stimuli in any degree, the susceptibility of excitation in the system is proportionally increased, till, by the continuance of that abstraction, the excitability totally disappears. We see then the most striking analogy in the effects produced by the too powerful action, and the total abstraction, of the necessary stimuli. In both cases, the organization may be so far deranged as to produce death; but if the operation or abstraction of the stimuli is not carried to this extent, in both cases debility is induced, attended with an increased susceptibility of the action of stimuli; or, in other words, a high excitability. There appears then to be no essential difference in those states of weakness which have been termed indirect and direct debility. This point we shall afterwards

wards take occasion to illustrate by examples.

By slow degrees, through the accession of new matter, the infant organization acquires firmness and vigour, till at length the animal body acquires its highest degree of perfection, constituting the state of manhood. In proportion to the increased vigour of the organization, the excitability is diminished. To produce action in the system, the force of the stimuli must be augmented: and the body can, with impunity, sustain the action of more powerful agents. The animal functions are carried on in their greatest degree of perfection; and the excitement or vigour of the system has attained its utmost possible height. The body is, however, as in the former period, liable to the same deviations from the healthful state, by the superabundant or diminished action of the different agents. But we observe a material change to have taken place; the animal body, having acquired its highest degree of perfection, is only capable

capable of having the vigour of its organization renewed by receiving new matter from the aliment, but is incapable of any further increase of size. Increased obesity is no contradiction to this fact; because, when carried to a certain extent, it undoubtedly constitutes disease.

As it is evident that the operation of stimuli, even of those which supply new matter to the body, has a continual tendency to exhaust the excitability, we must be convinced, that it is to the continued action, through the progress of life, of those agents, the operation of which is necessary to the production and continuance of that life, that we are to ascribe the state of weakness which constitutes old age. This period is marked by a debilitated organization, materially different, however, from the feeble organization of infancy; because, from the alteration which the animal fibre has undergone, it has become, in a considerable degree, incapable of being recruited, or restored to the healthful state, by the addition of new matter

matter from the aliment. In vain shall we endeavour to account for this new modification which has taken place in the organic structure of the body. The anatomist may point out some difference in the appearance of the parts in old age, and the former periods of life; and the chemist may demonstrate some variation in the proportion of the constituents; but their most diligent researches can afford us no information as to the cause of this alteration. And we are constrained to admit, that human investigation can carry us no farther than the bare knowledge of the fact, that in the more advanced periods of life, the powers of the system, in carrying on the animalizing process, are progressively diminished, till at length the animal fibre becomes absolutely incapable of assimilating or receiving new matter, and life necessarily ceases.

Old age is also obviously marked by diminished excitability. This, in most instances, is strikingly exemplified, by a diminished susceptibility of the action of stimuli

stimuli in the various organs of sensation. Light no longer produces its former effect upon the eye, nor sound upon the ear. The taste and smell decay, and the feeling becomes obscure. More evident proofs of diminished excitability cannot be supposed. Yet, in another view, an accumulation of this principle seems to attend old age. The operation of the more powerful stimuli, as alcohol or opium, produces a greater effect than in the middle period of life. A quantity of alcohol, which, at forty years of age, would scarcely have caused exhilaration, will, in the same person, at sixty or seventy years of age, produce intoxication. Hence it would appear, that old age, generally speaking, exhibits signs, both of an exhausted and an accumulated excitability. With respect to the former, it appears, that the organization is so far deranged, as to be less susceptible of the action of many of the external agents, as light, sound, &c. With regard to the latter, the apparent accumulation of the excitable principle,

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we are inclined to account for it, from the consideration of the fact just mentioned, that the animal fibre daily becomes more and more incapable of receiving new matter. This operates precisely in the same way as the abstraction of the necessary stimuli in the former periods of life. Hence the daily increased debility, and the consequent increased susceptibility of the action of stimuli.

In the progress of human life, we observe, by shades almost imperceptible, the feeble organization of infancy, rising to the firm and vigorous tone of manhood, and again sinking into the debility of old age. Through all the various modifications which take place in the fibre, we perceive the animal body more susceptible of the action of stimuli, in proportion to the weakness of the fibre, and less susceptible of that action, in proportion to its strength. To what then are we to ascribe the accumulation or exhaustion of excitability, but to the various modifications of the organization? And to what are we to ascribe

ascribe these various modifications, (we speak only of the state of health), unless to the progressive capacity and incapacity of the animal fibre for receiving an accession of new matter?

But the addition of new matter alone is not sufficient to preserve the animal fibre in the healthful state; rest is also required: and nature has allotted a considerable portion of our time to this purpose. The periods of watching and of sleep very clearly exhibit the diminution and increase of the excitable principle. We go on, therefore, to consider the principle of excitability, or the modifications which take place in the organization, in a second point of view, viz. as producing the alternation of the waking and sleeping states.

It seems clear, that through the course of the day, or during the continuance of the waking state, the organization becomes debilitated by the action of the ordinary stimuli, as heat, light, sound, air; but especially muscular motion, and the passions of the mind. After these have

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acted upon the body for a certain period, it becomes no longer susceptible of the action of these stimuli. An inert state succeeds, in which we perceive a partial suspension of the animal functions. The ordinary stimuli, during this period, have little or no effect upon the body, at least none of those functions are exercised which depend upon the will.

That the excitable principle is in this case exhausted by the continued action of the stimuli seems clear, because the same effect may be produced, and with still greater celerity, by the excessive action of various stimulant powers. Thus too large a proportion of aliment, or the operation of [heat in a certain degree, will induce sleep. Still more rapidly is this effect produced by the action of the more powerful artificial agents, as opium, alcohol, &c. Since then sleep is rapidly produced by the operation of powerful stimuli, we may reasonably infer, first, that this state necessarily succeeds the exhaustion of the excitability to a certain degree; and, secondly,

condly, that in all cases it is effected by the action of stimuli. The same effect which follows the operation of the more powerful stimuli in a short period, is in a longer time produced by the ordinary healthful agents.

We cannot however ascribe the state of sleep, in every case, to a simply stimulant action in the powers which produce it. By the labours of the day, a considerable quantity of matter is separated, and thrown out of the body, by the various excretions. The animal fibre is weakened by the loss of this matter: and hence it is, that although the more powerful stimulants will produce the state of sleep, yet the same substances, administered in a proper proportion, will preserve the waking state. Thus a person exhausted by labour and long watching, may be kept awake for a further time by a moderate meal. In like manner, a dose of opium or alcohol will protract the waking state. Now, although the natural aliment does not furnish new matter to the system at

the instant it is received into the stomach, and although opium and alcohol do not contribute new matter to the body; yet the whole of these produce a temporary vigour and energy in the system, which for a short time renders it susceptible of the action of the natural stimuli, and hence the waking state is protracted.

The state of sleep may then be produced by two causes: First, The organization is debilitated by the stimulus of labour, and the other agents, during which a quantity of matter is separated from the animal fibre, and not sufficiently replaced. For although we receive aliment repeatedly during the day, it is at least probable that the new matter is not deposited during that period in the same proportion in which it is carried off. Hence the organization is weakened, producing in fact that state which has been termed direct debility. But we believe it has not hitherto been suspected, that the powers operating upon the body through the day really produce that state.

Secondly,

Secondly, The sleeping state is induced by the operation of the more powerful stimuli, during which we do not perceive that the animal fibre is exhausted by the diminution of matter; but the organization is debilitated by the excessive action of the stimulus producing what has been termed indirect debility. In both cases, a debilitated organization appears to be the cause of sleep.

We have already suggested, that there does not appear to be so great a difference between direct and indirect debility as has been very generally supposed. Direct debility is caused by the abstraction of those agents which are necessary to the continuance of life. To take aliment for our example, — Debility is soon induced by the total abstraction of food. The cause here is perfectly obvious: The matter of the animal fibre is diminished by the usual excretions, and it has not received a new supply. Hence the weakened organization. Indirect debility is produced by the excessive action of stimuli. Is
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it not the necessary effect of stimuli, especially the more powerful, to increase the secretions and excretions? May we not then suppose, that the more powerful stimulants rapidly diminish the matter of the animal fibre by accelerating the secretions, thus producing precisely the same effect with the abstraction of aliment? Is it not probable that the weak organization which follows the abstraction of aliment, and the excessive action of alcohol or opium, is in a great measure produced by the diminution of the matter of the animal fibre? We are aware, however, that all the effects produced by the operation of strong stimulants, cannot be accounted for merely on the supposition of the abstraction of matter from the body by the ordinary excretions. Nor can the effects which arise from the total abstraction of several of the natural stimuli be accounted for on this principle. The abstraction of air, for example, will in a very short period produce death; and in this case no considerable diminution of
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the constituents of the body takes place. Nor is there any such diminution when death is produced by a large dose of alcohol or opium. It follows, that we cannot account for the action of all stimuli upon the same principles: and we shall have occasion, when treating on the different agents, to show, that various stimuli differ not only in the degree of their power, but also in their nature and mode of operation. We are however disposed to think, that a debilitated organization, whether caused by the abstraction or the too powerful action of stimuli, i. e. both direct and indirect debility, arises, generally speaking, from too great a diminution of the animal matter.

Whatever may be in the preceding observations, it is plain that the state of sleep, in every instance, takes place in consequence of an enfeebled organization. Upon this principle, we can explain the cause why sleep is induced by the abstraction of heat. A person subjected to a very low temperature, especially if not stimulated
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by action, quickly becomes drowsy. The abstraction of the necessary stimulus of heat debilitates the fibre.

Debility then produces that partial suspension of the animal functions which we term sleep. In this state, the body is subjected only to the stimulus of the blood,—the other fluids,—the air in respiration,—and external heat, according to the degree of temperature in which the body is placed. In proportion to the debility induced, or previous exhaustion of the excitability, provided the organization is not too much weakened, will be the soundness and continuance of the sleep. After continuing in this state for a certain period, the susceptibility of impressions from the usual stimuli is restored to the body. This reproduction of the excitability, appears to be caused by the abstraction of the usual stimuli which had acted upon the body during the waking state, together with the addition of new matter to the fibre, by the animalizing process which is carried on during sleep, in the circulating

ting fluids. Hence, new energy is communicated to the system, the tone of the fibre is restored, and it is rendered capable of being excited by the natural stimuli. It requires no arguments to prove that the vigour of the system is restored by sleep: and it is plain that the action of stimuli, during the day, renders the body less capable of excitement in the evening, than it was in the morning. It follows then, that a particular modification of the organization being induced, and which appears to be a certain degree of debility, the excitability of the system is considerably diminished. But it must be here remarked, that a further degree of weakness than that which is necessary to induce sleep, is accompanied with an accumulated excitability, so that the body becomes much more susceptible of the action of stimuli, and the waking state is protracted so as to constitute disease. Thus, a debilitated organization, in most instances, is attended with watchfulness or disturbed sleep. Now, when the waking

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state is unduly protracted, or the sleep broken and disturbed, it seems clear, either that the excitability is considerably accumulated, or that the system is subjected to the operation of powerful stimuli. In every instance, perhaps, of this kind, where the waking state is not continued by the action of stimuli, the cause is sufficiently obvious, a debilitated organization, which consequently indicates an accumulated excitability.

Beside the more powerful stimuli already mentioned, the sleeping state may be prevented, and a morbid watchfulness induced, by excessive fatigue or the depressing passions. In the first case, a high degree of debility is induced by excessive fatigue, which, whatever it may be called, produces exactly the same effect as accumulated excitability arising from any other cause. The waking state is protracted, although no powerful stimuli are acting on the body, and sleep may even be induced, by employing some of the more powerful stimulants; the effect of which, must

must surely be, to exhaust the excitability. Here then is a case in which we should have expected an exhausted excitability. The continued action of the powerful agents, which produced excessive fatigue, as muscular motion, mental energy, &c. we should naturally have supposed, would have wasted the excitable principle, and have brought on rapidly the state of sleep. Such, indeed, is their effect, when acting in moderate proportion,—i. e. when acting in a certain proportion to the vigour of the animal organization. But when these powers act in a high degree, we find that they induce a modification of the animal fibre, which differs not in the least from that which is produced by the abstraction of stimuli, viz. a weakened state of the organization, with all the phenomena of accumulated excitability. It must, however, be remarked, that in some instances in which the waking state seems to be protracted by excessive fatigue, the operating cause is pain, arising from the violent or long-continued muscular action: And it

may be admitted, that in these cases, sleep is prevented by the operation of a powerful stimulus.

The second cause which we have mentioned of morbid watchfulness, is the depressing passions, as fear, sorrow, grief. The uniform effect of these powers upon the body, is to debilitate the organization. In no case do they produce energy in the system; and we should therefore be inclined to consider them as direct sedatives. We defer, however, the consideration of their nature, till they come more particularly before us. But the effect of their operation is perfectly obvious. The animal fibre is enfeebled, and an accumulated excitability always attends their operation. The cause, then, of morbid watchfulness in both the cases we have mentioned, is a debilitated organization, by which the body is rendered more susceptible of the action of the various agents, than in the perfectly healthful state. And to the same cause, we must ascribe the watchfulness

fulness which attends many cases of disease.

The partial interruption of rest which we experience in dreaming, appears to arise from a greater or lesser degree of debility in the organization. It is a fact universally known, that persons under a great debility, are much more liable to dream, than those of vigorous constitutions. Indeed, the sleep of the former is generally a constant succession of dreams. Thus, we observe, females, generally speaking, are more subject to dream than males. In every instance, those persons who are much accustomed to dream, exhibit a debilitated organization, and a consequent increased susceptibility of the action of stimuli. In this weakened state, the mental energy alone is commonly a sufficient stimulus to produce dreaming, and the effect is proportionally increased, by the operation of the stronger passions of the mind. Material stimuli, as an overloaded or disordered stomach, will produce the same effect, not only

only in debilitated habits, but proportionally in the more vigorous.

Somnambulancy appears to arise from the same cause, but operating to a greater extent than in ordinary dreams. In this disease, we perceive accumulated excitability strongly marked. And to what cause can we assign the excess of this principle, unless to the enfeebled organization, which is constantly present.

Upon the whole, it appears that the vigour of the body is diminished during the course of the day by the operation of the usual agents; and if the debility induced is carried only to a certain extent, its susceptibility of the action of these agents is also diminished. In this case sound or healthful sleep succeeds: And after a certain period, the body, recruited by rest, as well as the addition of new matter, reassumes its former vigour, and becomes again susceptible of the action of the usual stimuli. But if the degree of debility induced is considerable, whether caused by labour or disease, we find that
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the body retains its susceptibility of the action of stimuli, and indeed exhibits all the phenomena of accumulated excitability. These cases of increased debility, by which the watchful state is protracted, have been considered as instances of exhausted excitability, or indirect debility. We have seen, that they are in fact attended with what is usually termed accumulated excitability: But, as we have already said, there appears to be no real difference in those states of the organization which have been distinguished by the terms direct and indirect debility.

Various degrees, however, of excitability, or that susceptibility which the animal body possesses of being excited to action by stimuli, appear not only in the different periods of human life, and in the alternation of the waking and sleeping states, they are also observable in an individual at any given period of life, or in two persons at the same period. But in every instance these variations will be found to arise from some change taking place

place, in the animal organization, by which, in a greater or lesser degree, it has been debilitated, or received an accession of strength. We shall endeavour to illustrate the subject in this third point of view.

Let us here take for our example a person arrived at the age of manhood, and possessing a vigorous constitution; the various natural or healthful agents acting upon him, and employed in a due or moderate proportion: in this case we observe all the animal functions duly performed, and the vigour of the body carried to its utmost height. This is the highest state of excitement of which the system is capable; or, in other words, the organization is now in its most perfect state. We may next consider what will be the effects of abstracting, or employing in too great proportion, the natural stimuli.

If the natural stimuli are abstracted in any degree, a proportional degree of weakness will be produced in the system. This is perfectly obvious, if the natural stimuli of heat or aliment are withdrawn
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in any considerable proportion. The organization is evidently debilitated:—The powers of life or excitement are diminished; and, it would seem, the excitability is augmented in an equal ratio. That the powers of life are diminished, will not be disputed: And the seeming proportional increase of the excitability, appears to be proved by a great number of facts. If a person has fasted long, a small proportion of any of the natural stimuli will produce a much greater effect upon the system, than a larger quantity would have done if the body had not been debilitated by the abstraction of the usual stimuli. The stimulus then, in this case, seems to have a much greater effect than it would have had if similar agents had been regularly applied to the body. Again, when the abstraction of the usual stimuli has been carried to a very considerable extent, as when a person is nearly famished, a very small proportion of a mild substance, as a few spoonfuls of broth, if hastily swallowed, will produce the same effects as a

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strong stimulant, such as alcohol, would have done if the organization had not been thus debilitated. The mild stimulus will in this case produce the usual exhilarating effects of spirituous liquors ; and instances have even been known, in which a small quantity of broth has produced death, in the same manner as a large quantity of alcohol would have done in a system not debilitated by the abstraction of the usual stimuli. These effects sufficiently show, that in that state of weakness which is induced by the abstraction of the necessary agents, the organization is more easily excited to action than in the healthful state ; and hence it has been supposed that the excitability is accumulated. It is, however, perfectly clear, that the abstraction of one or more of the necessary or usual stimuli, will produce a derangement of the organization, which is uniformly marked by debility. But the derangement to which the organization is liable, may be varied in several ways, according to the nature and use of the stimulus, and

and the proportion in which it is abstracted, so as to produce, no doubt, several very different modifications of the animal fibre. The effects produced on the body by the abstraction of different stimuli, we shall state more particularly when treating upon the agents: at present it is sufficient to observe, that by the abstraction of aliment, the organization is debilitated, because the animal fibre has not received that accession of new matter which is necessary to preserve it in the healthful state. By the abstraction of heat, i. e. when the body is placed in a low temperature, as at 32° or under, the animal heat is carried off in a greater proportion than that in which it is produced in the body; and the animal fibre, deprived of the necessary quantity of this stimulus, appears to be incapable of performing its usual functions. Upon similar principles, we may explain the cause of the derangement of the organization from the abstraction of several other of the healthful agents. But it must be confessed, that the mode in

which some of these agents operate, and by which they assist in preserving the body in the healthful state, have hitherto excluded the researches of all physiologists. The fact however is plain, that the abstraction in any degree of all or any of those powers which are necessary to the production and continuance of the phenomena of life, induces a debilitated organization; and the body thus weakened, appears to become more susceptible of the action of these or other agents.

Upon the other hand, the organization of the same person, or of another of an equally vigorous constitution, may as easily be deranged by the same agents acting in too high a degree. Thus, too large a quantity of aliment will, in a certain period, produce debility. The same effect more rapidly follows too free a use of the artificial stimulants, as alcohol, or any substance containing it. And if the total abstraction of the healthful agents will quickly annihilate the excitement, or destroy life; so also the same agents, operating

rating in an extreme degree, and more especially the artificial stimuli, will quickly so much derange the organization, that the animal functions can no longer be carried on.

There is, however, a material difference in the first effects produced on the body in these two cases, although they both terminate by producing a debilitated organization, which seem in no respect to differ. A small abstraction of the natural agents produces a flow, and, perhaps, for some time, an almost imperceptible waste of the system; and the animal fibre is gradually debilitated. A small increase beyond the due proportion of the healthful agents, or a moderate use of the artificial stimuli, causes, for a short period, an increased vigour of body, and, in most instances, an increased accession of matter to the system. But if the practice is continued, and more especially if the excess of stimulus is increased, a debilitated organization infallibly ensues. In the final effects arising from these two opposite causes,

causes, we perceive no difference. By the first, debility may slowly commence, and gradually increase, in proportion to the degree in which the necessary agents are abstracted, till, if not prevented by the proper remedies, the organization is totally deranged, and death follows: and during the progress of this debilitated state, from the increased weakness, the body becomes daily more susceptible of the action of stimuli. By the second, a degree of vigour in the organization is certainly, in the first instance, produced: but by the continued action of too powerful stimuli, the organization becomes deranged, debility ensues, and the system, as in the former case, becomes daily more susceptible of the action of stimuli. The states of direct and indirect debility, as they have been called, when the latter is fully established, appear not to differ in their nature. And hence it seems a fair conclusion, that the method of cure, in both cases, ought to be the same.

That the debility induced by the action
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of too powerful stimuli, differs not from that which follows the abstraction of the necessary agents, may be further proved, by the well-known effects of the more powerful artificial stimuli. We have already hinted at this, and may here farther observe, that we perceive no accumulation of the excitability when a person is indulging in strong liquors even to intoxication. But no sooner has the operation of the stimulant ceased, than we perceive a debilitated organization, in proportion to the excess in which the stimulus has been employed; and this debility is uniformly accompanied with a higher susceptibility of the action of stimuli. It does not, therefore, seem true, in fact, that the debility which follows the excessive use of stimulants arises from an exhaustion of the excitability: It is true, that an extreme dose of alcohol or other stimulants will at once destroy the excitability and excitement; but the same effect will follow from the total abstraction of the healthful agents. In almost all cases
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the debility induced by the excessive action of stimuli, is certainly accompanied with a greater susceptibility of the action even of the stimulant which has produced the debility. It must, however, be admitted, that opium furnishes a contrary example: for as far, we believe, as observation has hitherto gone, it appears, that in the continued use of this drug, an increased dose will always be necessary to produce the usual degree of excitement. Yet even in this case it is certain, that a constitution debilitated by the use of opium, acquires an increased susceptibility to the action of other strong stimuli: And the only conclusion that we can rationally draw from the fact, that the dose of opium must be perpetually increased, is, that various stimuli differ, not only in their degree, but also in their mode of operation.

We may now conclude this view of the principle of excitability with the following observations, which seem clearly to result from the facts already stated.

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First, The effects of stimuli upon the animal body, are, generally speaking, in proportion to the vigour of the organization. Hence, in the middle period of life, the animal fibre can sustain the action of those stimuli which in childhood or old age would produce death.

Secondly, As the natural effect of all stimuli, and even of the mildest healthful agents, is ultimately to derange and debilitate the organization, it seems obvious that such debility cannot be removed, but must be increased, by a free use of powerful stimulants. The natural method of removing debility, in every case, surely, is by employing in due proportion the necessary healthful agents, particularly aliment. The judgement of the practitioner should be chiefly employed in the choice of the most nutritious and easily digested substances. The use of strong stimulants, in a very moderate degree, is, no doubt, admissible; but their only use can be, to excite the action of the stomach and intestines, and to give

a temporary vigour to the system, which is favourable to the digestive process. The opinion which has been held out, that the accumulated excitability, supposed to exist in cases of direct debility, must be removed or wasted by the use of powerful stimulants, has led to an extremely dangerous practice. Can it be reasonably supposed, that the extreme debility, which in many cases is almost instantaneously produced by the contagion of typhus, is to be removed by such a quantity of strong stimulating liquors, opium, &c. as would exhaust and debilitate the most vigorous constitution in the highest state of health?

Thirdly, If an excessive use of powerful stimuli exhausts the excitability, it would naturally follow, that in the cure of indirect debility all stimuli should be withdrawn, except those of the lowest degree, that the diminished excitability may again accumulate. Yet even here, the highest stimulus has in the first instance been proposed, with the view, indeed,

deed, of gradually diminishing it. The total abstraction of strong stimuli may perhaps be improper: But certainly the use of that power, in the same, or nearly the same degree by which the disease was produced, can only augment the disease.

Fourthly, It has been very generally supposed, that the animal body is not only subject to diseases of debility, but also to diseases of over much strength, or the sthenic diathesis, as it has been termed; and this state is said to be produced by the use of various stimuli in too great a proportion. But as it is indisputable, that all stimuli exhaust and debilitate the organization, is it not to be suspected that this diathesis has no existence in nature? For if debility immediately succeeds the operation of a powerful stimulus, how can the sthenic diathesis be supposed to exist after the stimulus has ceased to act? Besides, it seems a little incongruous in language to call the highest state of health a disease. Perhaps it would not be difficult to explain the nature of those diseases

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which have been ranked in this class upon very different principles, and to prove that they are the effect of a debilitated organization. But we leave the consideration of this point at present, and only suggest, that at least it deserves some attention.

The modifications to which the animal organization is liable, and by which the excitability of the body appears to be increased or diminished, and the powers of life or excitement rendered more or less vigorous or languid, are extremely various, nor is it perhaps possible to reduce them to general principles. These effects evidently follow the action or abstraction of the different agents we have already mentioned; and to a brief consideration of which we now proceed, in the order formerly stated. In treating of these agents, we shall have occasion to show, that although the greater part of them undoubtedly possess a stimulant power, yet many, and perhaps all, operate also upon different principles, by which various

rious alterations are produced in the animal fibre.

We begin with the consideration of heat: and at present we confine ourselves to external heat, or the effects produced upon the body by the temperature in which it is placed.

It is unnecessary here to point out the nature or sources of heat: nor shall we enter into any discussion of the question, Whether heat is a species of matter really existing, or whether it is merely a modification of matter? There are sufficient reasons to induce us to assume the former opinion. From a variety of facts we can scarcely avoid concluding, that there exists in nature a species of matter *sui generis*, and which appears to be a subtile elastic fluid, to the operation and various modifications of which we must ascribe all the phenomena of heat. This fluid has received the distinctive name of caloric from the modern chemists.

That the operation of the caloric is essential to the production and continuance of

of life in all organized bodies, is too obvious to require particular proof. With respect to the human race, the range of temperature favourable to health is probably between the 32d and 80th degrees of the scale of Fahrenheit; and, generally speaking, the middle point between these is the most favourable to health. But in proportion as the temperature recedes, i. e. if it sinks below 32° , or rises above 80° , it becomes injurious to health, and destructive of life. But by several wise provisions in the œconomy of nature, and especially from habit, individuals are enabled to bear considerable variations of temperature, without much injury.

As the temperature induced in the animal body, by the evolution of the caloric in the respiratory process, is in the healthful state from 96° to 100° ; and as the medium which we inhabit is almost always below, and generally very much below that temperature; it is plain that we do not receive heat from the surrounding atmosphere, nor from any other substance,
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unless it is of a higher temperature than our bodies: And as, to preserve the healthful state, it is not necessary that the temperature of the medium in which the body is placed should be above 60° , it is plain that the animal body requires no additional supply of the caloric from external substances. Hence it follows, that the beneficial or injurious effects derived from the temperature of the atmosphere, arise from the surrounding substances abstracting in too great or too low a degree the caloric from the system.

The operation of such external heat upon the body is therefore only negative. But the visible effects which variations of temperature produce upon all organized substances, compel us to include external heat in the list of agents which act upon the body. These effects are obviously stimulating. Numberless facts support this position. The diminished temperature at the close of autumn, and during winter, seems to extinguish life in almost all the vegetable kingdom. The cheering rays of the sun in the returning spring re-excite the
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action of the vegetable fibre; the sap rises, and new parts are evolved. Something similar to this is observed also in those animals which remain in a torpid state during winter, and which revive with the increased temperature of spring: And the experience of each individual of the human race, will sufficiently testify the genial influence of heat in promoting action in the organization of the body. The experiments of Spalanzani show that the action of the caloric is not only necessary to the production of life, but that the hatching process may be accelerated by an increase of temperature within a certain degree. Thus the evolution of the tadpole from the ovum of the frog is hastened by an increase of temperature. In like manner, the production of life in the chick *in ovo* is accelerated by placing the eggs in a temperature somewhat higher than that communicated by the parent animal.

Such however is the structure of the animal organization, that to preserve the vigorous and healthful state, the caloric must

must be applied to it only in a certain proportion. There is, as we have already said, a range of temperature favourable to life; and the middle point of this range, i. e. from 55° to 60° , seems most conducive to the vigour of the system. The extremes of climate in the habitable world are equally unfavourable to the perfection of the animal, and to the healthy state. At the medium temperature which we have mentioned, the surplus of that heat, which is perpetually evolving in the respiratory process, is duly carried off; and there seems to be at this point a happy proportion established between the action of the caloric and the animal fibre. But in proportion as the degree of temperature recedes from this point, we have reason to infer that it becomes injurious; because debility is induced by the extremes of heat and cold. Now, if this effect follows either extreme, every degree of deviation from the middle point must be proportionally injurious. And injurious effects would certainly follow every deviation

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from this middle point, were it not for those provisions in the oeconomy of nature at which we have already hinted, by which the human body can accommodate itself to a very extensive range of temperature.

The effects of the caloric, however, are like those of all other necessary stimuli: If acting in too great a proportion, debility succeeds; and if abstracted in too great a degree, a weakened state of the organization inevitably follows. The latter of these may be termed an accumulated, and the former an exhausted excitability: But in fact we see no material difference in the state of the organization produced in either case. Nay, precisely the same effects will in some instances follow these opposite causes. A high temperature, or a very low one, will equally induce sleep. This partial suspension of the animal functions seems plainly to indicate a diminution of the excitability; and when this state is produced by the stimulus of heat, we should perhaps be in no suspense to say, that

that the excitability was exhausted by the action of the caloric. But must we not, upon the same principles, infer, that the excitability is exhausted when sleep is induced by too great an abstraction of heat? we are however rather disposed to conclude, that a debilitated state of the organization is in both cases induced, which differs not in its nature, and can only be removed by the same means, viz. the body being gradually restored to a medium temperature.

It is well known, that the continued abstraction of heat in the high northern latitudes, concurring with other causes, considerably accelerates the production of that state of debility which constitutes scurvy. In like manner, the excessive action of the caloric in the torrid zone, assisted no doubt by other causes, produces diseases of debility, which differ indeed in their form, but perhaps not much in their nature, from those which follow the abstraction of heat. It is equally well known, that either the excessive action, or the abstraction of the

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caloric, will facilitate the formation of typhus fever. From this similarity of effects we cannot, with any propriety, infer an exhaustion of the excitability by the excessive action, or an accumulated excitability by the abstraction of the caloric ; but we clearly perceive a debilitated organization arising from both causes, and which, we are disposed to think, can only be removed, under all its various forms, by nearly the same means.

From this general view of the effects of external heat upon the animal body, we should be inclined to suppose that the caloric is a simple stimulant, i. e. that it does not, like aliment, communicate new matter to the system, but operates upon the animal fibre merely by its stimulant quality. But upon a subject of this kind it is necessary to speak with caution. We are little acquainted with many of the operations which take place in the animal œconomy. We cannot say what modifications the caloric may undergo in the body, or into what new combinations it may enter.

enter. There are many reasons which may induce us to believe that the caloric received into the body enters into chemical combination with other matters, so as to be changed into the latent state or combined caloric of the modern chemists. Hence it may be supposed to form a constituent of the body; and in that case, even this apparently simple stimulus will afford an additional proof, that the different agents which operate upon organized bodies, do not act merely as stimuli.

It is probable that the phenomena of light are produced by a modification of the caloric. This therefore appears to be the most proper place to introduce a few observations on the effects of light upon organized matter. Light indeed does not appear essentially necessary to the production or continuance of animal or vegetable life; for we find that the vegetating process may be carried on, and animal life is preserved in the healthy state, although light is wholly abstracted. Yet this substance is one of the common agents, which
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act, generally speaking, upon all the individuals of the animal and vegetable kingdoms. But we are perhaps less acquainted with the effects produced by light, than those almost of any other agent.

With regard to the vegetable kingdom, it is clear that the colour, odour, taste, and combustibility, are to be attributed in a great measure to the action of light. These qualities generally depend on the presence of volatile oils: And we find, that vegetables, which are natives of the warmer climates, and which consequently enjoy a greater proportion of light than those of other regions, possess these qualities in the highest degree. It is certain, then, that plants undergo very considerable alterations with respect to their constituents, in proportion to the degree in which they are exposed to the operation of light.

The effects of light upon animals are by no means so obvious as upon vegetables: Yet we observe, that even the colour of animals is in some degree affected by the operation of this fluid. Animals wholly
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deprived of light are changed to white. Such is the effect produced on the hair of animals during the long night of the arctic circle. A similar effect has also been observed upon those animals of other regions which, during a part of the year, seclude themselves from the light. Generally speaking, the colour of the human race varies, from jet black to the fairest complexion, in proportion as they are exposed, in a greater or lesser degree, to the action of light. Other causes may probably also contribute in producing all the different shades of colour, from that of the Negro to the Briton or the Dane; but the operation of light cannot be excluded. It is probable therefore that the constituents of animal bodies, as well as those of vegetables, are varied by the agency of light.

In consequence of its physical properties, light has a very considerable effect upon mankind. By producing the phenomena of vision, it becomes an agent for communicating a great variety of ideas to the mental faculty. It may from hence
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be the means of awaking either the agreeable or depressing passions: But these effects are rather to be ascribed to the object which the light presents to the mind, than to the operation of light itself.

The simple operation of light upon organic matter appears to be that of a mild and agreeable stimulant. Hence the pleasing sensation, the cheerfulness of spirit, which every one experiences from the strong solar light of a fine day. It may indeed be supposed, that heat also assists in producing that hilarity we feel in fine weather: and, in some measure, perhaps this is true. But every one almost is sensible of a superior degree of cheerfulness under a clear sky, in the coldest day, above that induced by a warmer temperature, when the hemisphere is clouded. A similar effect is also produced in a certain degree by a strong artificial light, such as the splendid illuminations of a theatre or a ball-room.

The stimulating quality of light is principally seen from its effects upon the eye;
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and in the operation of light upon this organ, we may trace all the usual effects of stimuli. If totally abstracted, the sight becomes weak; an apparent increase of excitability seems to be present; for the eye cannot bear the action of a strong light. But by the power of habit, as is the case with other stimuli, the organ becomes less sensible of the operation of this agent. Thus, as we have formerly hinted, persons who have accustomed themselves to exclude the light from their chambers, cannot sleep if it is admitted, although the system has undergone the usual exhaustion from the labours of the day. Others, again, fall into the state of sleep notwithstanding light is present, provided they have habituated themselves to its action during the period of sleep. The former also do not find sleep prevented by the admission of light, if they have been more than ordinarily exhausted by exercise. To persons whose eyes are weak, the stimulus of light is often extremely injurious. Its action, when extreme, like that of other

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stimulants, will totally derange the organization. Thus blindness has frequently been induced by the long-continued action of a strong solar light.

Actual observation, as well as analogy, shows that a certain proportion of light is necessary for the animal oeconomy. The increased or diminished action of this fluid, does not indeed produce injurious effects equal to those which follow the abstraction, or extreme action, of some other stimulants: but we find the total abstraction of light produces a debilitated organization, both in animals and vegetables; and the destruction of the power of vision is the most violent effect of the extreme action of this agent: yet its operation is not solely confined to the organ of vision, but, as we have already said, it is also capable of varying and modifying the constituents of bodies. In short, light appears to be a powerful agent, which, by its stimulant property, produces a variety of changes upon organic matter. If its operation is not absolutely essential to the production

production and continuance of life, yet its presence is actually necessary to effect a variety of purposes in the œconomy of nature, by which life is rendered much more agreeable than it could have been without this agent.

The third agent, to the consideration of which we proceed, is Air. It is a general fact, that air is necessary for the production and continuance of life in all organized substances, whether animal or vegetable. Neither animal nor vegetable life, therefore, can be preserved long *in vacuo*; but it is a recent discovery, which we owe to modern chemistry, that it is oxygenous gas, one of the constituents of atmospheric air, which is alone so peculiarly important to the animal œconomy.

Atmospheric air appears to be formed of two constituents of very dissimilar properties, the azotic and oxygenous gases. The bases of these two gases, viz. azote and oxygene, enter into the composition of animal and vegetable substances. By a variety of operations, which it would be

improper for us here to detail, we can separate the oxygen from atmospheric air; and we can obtain, from a great number of other substances, both the azotic and the oxygenous gases. In atmospheric air the proportions are seventy-two of azotic, and twenty-eight of oxygenous gas.

It is now well known, that combustion is supported by the oxygenous part alone of atmospheric air; or, more strictly speaking, that combustion consists in the union of oxygen with the substance burnt. Different species of matter, therefore, are more or less inflammable, in proportion to their affinity with oxygen. Animal respiration appears to be a process extremely analogous to combustion. The same change is produced upon the air during respiration, as in the combustion of carbonaceous matter.

For the performance of the important function of respiration, nature has supplied the human race with an organ of the most curious structure, in every part of which we see the most striking proofs

proofs of wisdom in the contrivance. It is unnecessary here to enter into a minute description of the various methods employed in the structure of the lungs, by which the introduction and expulsion of the air is facilitated,—by which the air is brought in contact with the numerous ramifications of the arteria pulmonis,—and by which all the purposes of respiration are effected. It is sufficient to observe, that the substance of the lungs is formed of a vast number of membranous cells, and of three kinds of vessels, to which we may add nerves. The whole of these vessels and nerves are interspersed among the cells, forming innumerable ramifications. The vessels of the lungs are, the bronchia, or air-vessels,—the pulmonary arteries and veins,—the bronchial arteries and veins,—and the lymphatics.

From experiments which can easily be performed on the human race, as well as other animals, it appears that those species which are provided with lungs respire only in consequence of the oxygenous gas contained

contained in atmospheric air; and the function of respiration is exercised with greater vigour, in proportion to the quantity of oxygenous gas contained in the air respired. Any other gaseous fluid, in which there is none of this pure air, is totally unfit for respiration, and will in a longer or shorter period destroy life, in proportion to the nature of the gas, and the strength and habits of the animal which respire it.

During the respiration of atmospheric air, two very important circumstances are observable. First, A quantity of air disappears; and secondly, The air which is expired differs materially from that which was inspired. Both of these circumstances are to be accounted for from the same cause,—the change which takes place in the air during respiration. The atmospheric air which we inhale, is a mixture, as we have already said, of seventy-two parts of azotic, and twenty-eight of oxygenous gas. The air which is expired, when reduced to the temperature of the atmosphere,

atmosphere, is considerably diminished in bulk; and it is now found to consist of the azotic, carbonic acid, and oxygenous gases. The azotic gas of atmospheric air is returned, in expiration, undiminished in quantity, and unchanged in quality: a considerable proportion of the oxygenous gas has disappeared, and a quantity of the carbonic acid gas is found, which was not present in the air which was inspired.

Upon the whole it appears, that during respiration no alteration takes place upon the azotic gas contained in atmospheric air; it is expelled in the same state and quantity in which it was received. A considerable proportion of the oxygenous part of the air disappears, and a large quantity of the carbonic acid gas is produced. From hence we may conclude, that a process precisely similar to combustion takes place, either in the respiratory organ, or throughout the animal body. The carbonic acid gas is beyond dispute a product of combustion. Now, the disappearance

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of the oxygenous, and the evolution of the carbonic acid gas, can only be accounted for upon one or other of the following principles: First, It may be supposed, that a slow combustion of carbonaceous matter takes place on the internal surface of the lungs, by which the whole of the oxygenous gas which disappears, is changed into the state of carbonic acid gas; or secondly, Perhaps the oxygenous gas which disappears, is absorbed, and conveyed into the circulating fluids, and during the course of circulation is united with carbonaceous matter, forming the carbonic acid gas, and which is exhaled from the lungs during respiration. Before we attempt to give any determination upon this subject, it is necessary to consider what effects are produced on the blood by the respiratory function. These are chiefly two; first, the colour of the blood is changed; and secondly, heat is evolved. It has long been known, that the arterial blood possesses a bright vermilion colour, and that the venous is much darker,

darker, in some cases approaching nearly to blackness. Now, it is observed, that the dark-coloured venous blood, transmitted by the arteria pulmonis, undergoes a considerable change in its colour when in the lungs; so that the blood which is returned by the pulmonary veins possesses a bright vermilion hue. A similar effect is produced upon the venous blood when exposed to atmospheric air. After it has stood for a while, we observe it to acquire a more florid colour. This effect is produced with more rapidity, if the venous blood is placed in contact with oxygenous gas: The vermilion colour is quickly induced; and a similar change is produced on the air placed in contact with it, to that which takes place during respiration, that is, the bulk of the air is diminished, and a quantity of carbonic acid gas is formed.

Now, as the colour of the blood returned to the heart by the pulmonary veins has acquired the vermilion hue, it is natural to suppose, that the whole change produ-

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ced upon the blood by the oxygene is effected in the lungs. Yet when we consider, that if blood is placed in contact with atmospheric air, or oxygenous gas, even out of the body, the same effect is produced, it remains doubtful whether this change solely takes place in the lungs, or whether oxygenous gas is not absorbed in the lungs, and conveyed into the circulating fluids, and so produces this change of colour, by uniting with carbonaceous matter in every part of the arterial system.

The second effect produced during respiration, is the evolution of heat. The cause of animal heat has in all ages attracted the attention of philosophers; and many theories have been formed to account for this phenomenon of the animal œconomy, the most of which seem merely hypothetical. The first philosopher who paved the way for the development of this important subject, was the celebrated Dr Black. He first attributed the production of animal heat to the process of respiration.

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The same theory was further illustrated, and in some degree modified, by Dr Crawford, in his treatise on animal heat. Much light has also been thrown upon this subject by the discoveries of many of the modern chemists. We shall not however narrate the gradual progression by which this theory has arrived at that degree of perfection in which we now find it. Nor is it necessary to enter into any particular illustration of the doctrine. It is sufficient to observe, first, That in respiration a quantity of oxygenous gas disappears, and a portion of the carbonic acid gas is produced. It follows then, secondly, That respiration is a process perfectly analogous to combustion; and thirdly, That during the transmutation of the oxygenous into the carbonic acid gas, a considerable quantity of the caloric must necessarily be evolved.

When we consider the large quantity of oxygenous gas which disappears during respiration, and the great difference in the relative capacities of the oxygenous and

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carbonic acid gases for receiving heat, we see, in the respiratory process, a cause abundantly sufficient for the production of animal heat. And as this cause is perpetually operating, there would be a surplus of heat produced in the animal system, were it not perpetually going off to the surrounding bodies.

Now in this method of accounting for the production of animal heat, it is not material whether we suppose that the transmutation of oxygenous into carbonic acid gas takes place in the lungs, or whether the oxygenous gas is absorbed in the lungs, and mixed with the mass of circulating fluids. In the latter case, we must suppose that the oxygenous is changed into the carbonic acid gas in every part of the arterial system, and that the carbonic acid gas is thrown out from the circulating fluids during their passage through the lungs. In either case, however, the effect is the same. Oxygen separated from the respired air, unites with carbonaceous matter in the lungs, or in every part of
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the arterial system; and the caloric must in either case be evolved.

We may now briefly state the effects produced in the animal œconomy by the process of respiration. The first, as we have observed, is, producing a change in the colour of the blood during its passage through the lungs. The change of colour is produced by the separation of carbonaceous matter from the blood. This separation is proved by the formation of carbonic acid gas in the lungs. Thus far the process of respiration is perfectly analogous to combustion. Whether any portion of the oxygen, which disappears in respiration, is united to the blood, seems at least to be doubtful. But it is evident, that the blood has undergone a very considerable change in its appearance and qualities. The florid colour, and the peculiar qualities which it has acquired in the lungs, is in a greater or lesser degree preserved through the arterial system, but are entirely lost in its progress through the venous system. There can scarcely be any doubt,

doubt, that the qualities acquired by the blood during its passage through the lungs, render it a more powerful stimulus to the heart and arteries, so as to be more capable of exciting their contraction. But the proofs of this point we must defer, till we consider the action of the circulating fluids as an exciting power.

The second use of air in respiration, is the production of animal heat. The evolution of the caloric in the lungs, is a consequence which must unavoidably follow the process which takes place in that organ, viz. the production of the carbonic acid gas. The heat of animals is uniformly found to be in proportion to the size of the lungs, the capacity of this organ for performing its functions, and the nature of the air which is respired. The lungs therefore must be considered as a focus of heat, from which the whole system is supplied. In proportion to the size of the lungs, a greater or lesser quantity of oxygenous gas is changed into the state of carbonic acid gas. If the lungs are in an unhealthy

unhealthy state, as in an asthma, this change takes place only in a small degree, and a proportionally less quantity of the caloric is evolved. There are however other cases of disease, as in phthisis pulmonalis, in which there seems to be an increased action of the lungs, by which a larger proportion of carbonaceous matter is separated from the blood. That such an effect takes place, seems to be proved by the very florid colour even of the venous blood in this disease; and also by the increased heat which is present in the system. It is remarkable, that these effects are produced, even after a considerable portion of the substance of the lungs has been destroyed by the disease *.

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* Whether any advantages will be derived from causing patients labouring under these, or other diseases, to respire air modified by the mixture of different gases, is to me exceedingly problematical. It would however be premature to give any opinion upon this subject, because experiments are yet wanting to determine whether beneficial or injurious effects will result from the practice. It is to be wished that Dr Beddoes may succeed in the attempt in which he is at present engaged, of forming an establishment

The heat thus evolved in the process of respiration is one of the most important agents in producing and continuing the phenomena of life. We have already proved, that the operation of heat is indisputably stimulant: and it only remains here to observe, that the heat necessary for animal life is evidently produced by the respiratory function. It appears that the temperature of animal bodies cannot be considerably increased or diminished by external causes, unless these causes operate in extreme degrees, as appears by the experiments of Drs Fordyce and Blagden *.

In taking an accurate view of the operation of oxygene in respiration, three effects appear to be produced, which are immediately necessary for the continuance of animal life. First, A quantity of carbonaceous

ment for applying the gases in different diseases with that accuracy, and in such quantities, as may afford a perfect decision with respect to the propriety of the practice.

* *Vid.* Philosophical Transactions, Vol. LXV.

bonaceous matter is separated from the blood. This is sufficiently evidenced by the production and expulsion of the carbonic acid gas. As a quantity of carbonaceous matter is expelled during respiration, we must conclude that the retention of this matter would have been injurious to the system. We cannot however suppose, that the mere retention of a small portion of carbone is the immediate cause of that sudden cessation of the powers of life, which is produced by the total abstraction of oxygene for a very short period.

The second effect of oxygene in respiration, is the evolution of heat. This is also equally essential to animal existence: for if heat is not produced in a due proportion, undoubtedly disease will follow. It does not however appear that sudden death by the abstraction of oxygene, is caused by a diminution of sensible heat in the animal body; but this effect of respiration, the evolution of heat, must be considered

considered as of the highest importance to the animal economy.

The third effect of oxygen in respiration, is the change produced on the arterial blood. That a very important alteration is produced in the colour and qualities of the blood during its passage thro' the lungs, and that this alteration is in some way produced by the oxygen which disappears during respiration, is fully proved by experiment, and is indeed universally allowed. The blood, by this change in its qualities, appears to become a proper stimulus for exciting the action of the heart and arterial system. This, we apprehend, may be proved, from a clear induction of facts, which we shall have a more proper opportunity of introducing when treating on the stimulant power of blood. If, however, this change in the qualities of the blood is not perpetually effecting in the lungs, the powers of life will be quickly suspended. If oxygenous gas is wholly abstracted from any animal, the first effect which follows

follows is an impeded circulation, and quickly the heart and arteries cease to beat. The powers of life are then entirely suspended. With the greatest probability, we may attribute the sudden cessation of life, during the abstraction of oxygen, to the blood being no longer a proper stimulus for exciting the action of the heart and arteries; and this evidently arises from the usual change not taking place in it by the respiratory function.

It appears then, from the effects, of oxygenous gas in respiration, that it cannot be considered merely as a simple stimulus to the body; nay, its operation seems chiefly to depend upon its chemical qualities. Whether oxygen, during respiration, is or is not received into the circulating fluids, so as to become an actual constituent of the body, certainly has not been decided; but it is plain, that in either case, oxygenous gas produces a very material change in the state and qualities of the blood, by which that fluid is fitted to act as a proper stimulus to the animal

fibre of the heart and arteries. The oxygenous gas, therefore, operates in this case as a chemical agent; and there can be little doubt, that by the alteration which is thus induced in the state of the blood, an equally material change is produced in the animal fibre, which receives its nutrition from the blood. We have therefore, in oxygenous gas, another example of a natural or healthful stimulus, which acts upon the animal body, not only by its stimulant power, but also by its other qualities. It is equally clear, that oxygenous gas differs from many other stimuli, not only in the degree of its power, but also in the nature of its operation.

Before we entirely quit the consideration of the effects of air as a stimulant to the animal system, it seems proper to add a few observations upon the nature and effects of sound. We shall therefore introduce this as the fourth natural agent or stimulus. The operation of sound, as we have already observed, is not absolutely necessary, either to the production or continuance

tinuance of animal life. Of this we have daily an opportunity of observing a clear proof, in many of our species who are not possessed of the power of hearing: yet it is equally clear, that excepting in these few instances, sound is an agent capable of producing the most powerful effects upon the animal body; and in the human species we often witness its operation in a great variety of modes. Though it is not absolutely essential to the production or continuance of life, it is at least of considerable importance, and is capable of being employed as one of the artificial stimuli, by which very considerable alterations may be produced in the state of the human system.

Sound, by whatever substance produced, appears to be received and transferred only by those substances, the parts of which are capable of being easily moved, so as to change their relative situations. But some substance is absolutely necessary to convey sound, because we find it is utterly lost in vacuo, and it is increased in proportion

proportion to the density of the air. Elastic fluids form the most common, and perhaps the most convenient medium for transferring sounds. At one time it was supposed that sound was conveyed by air alone. The ingenious Professor of Anatomy in this University has however showed, in his treatise on the Physiology of Fishes, that sound is also conveyed by water, and nearly with as much rapidity as by the atmosphere. Other inelastic fluids must also be able, in certain degrees, to produce the same effect. To form sound, the motion or collision of bodies is requisite. By this motion or collision, a tremor or vibration is induced in the transferring medium. There is an evident impulse on the medium through which sound is conveyed, produced by the motion or collision of bodies. This impulse is supposed to produce certain oscillations in the air, or any other medium capable of conveying sound, by which its plane surface is alternately elevated and depressed into the form of arches or curves,

curves, so as to form a succession of sonorous waves. The impulse received by the transferring medium, is by it conveyed to the organ of hearing. Hence we may fairly conclude, that the sensation received from sound in the sensorium commune is produced by an actual impulse on the external organ of hearing. That the sensation which we call sound, is produced by an impulse on the sentient extremity of the auditory nerve, may be further supported from other phenomena of sound. The oscillations of the air produced by the motion or collision of bodies, succeed each other with a certain velocity, proportioned to the force of the motion or collision. And it appears, that to produce an audible sound, at least thirty of these oscillations must be produced in a second of time. Now, it seems clear, that in proportion as the vibrations in the transferring medium are, in a given time, few or many, the impulse on the organ of hearing will be strong or weak. When the vibrations are few, the impulse upon the

the organ of hearing is so faint as to be imperceptible.

As the sensation of sound appears to be produced by a direct impulse, we have reason to conclude that it operates upon animal bodies by a stimulant power.

The operation of sound is chiefly observed in effects produced upon the mental powers. Sound, however, may be employed, and it may produce on the mental faculty the most powerful effects, while yet those effects are not to be ascribed to the sound itself, but to that which is expressed by it. Thus sounds expressed by the human voice may be employed in the delivery of historic facts,—the narration of a tale of woe,—in describing a comic scene,—or upon any other subject which may excite emotions in the human mind: pity, grief, or horror may be awakened;—mirth, joy, esteem, love, or admiration may be excited; yet the producing of these emotions is not wholly to be ascribed to the sounds which have been employed, because, had the same facts.

facts and circumstances been submitted to the eye in reading, the same passions would have been excited in minds possessed of sensibility. It is true, the effect of eloquence depends in a great measure on music; for, in the large and proper sense of the word, music has been styled, the art of variously affecting the mind by the power of sound. The most illiterate and vulgar minds are in some measure capable of feeling the power of a justly modulated voice, rising or falling by successive harmonious notes, and changing to various keys, as the subject may require. The whole effect of oratory, however, is not to be ascribed to the powers of the speaker; the influence of the matter delivered, must be distinguished from that of the manner in which it is pronounced. In estimating, therefore, the power of sound in oratory upon the human mind, we must deduct a considerable share as properly belonging to the subject, and not to the sounds by which it is expressed. In the mere enunciation of facts by the

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human voice, in the ordinary occurrences of life, the mental powers are frequently affected in a high degree. But here the influential power is not the sound of the voice, but the fact announced. It is by the power of sound, unaccompanied by human language, that we must endeavour to appreciate the influence of this stimulus upon the mental power of man. In the effect of music, we have an opportunity of observing its full force.

Particular combinations of sound seem naturally to inspire joy; others have an equal effect in producing melancholy; in short, every passion and emotion of the mind may be produced by proper combinations of musical notes. These effects take place in consequence of an impulse upon the organ of hearing, by those oscillations of the air which are produced by a musical instrument. The auditory nerve in this case is evidently the immediate organ of sensation; and it is equally clear, that by this impulse some modification, though altogether unknown to us, must

must take place in the sentient organ, by which the peculiar ideas expressed by the musical sounds are awakened in the mind.

But is the operation of sound in all cases the same? Does every possible combination of sound stimulate the system? Or does not sound in many cases produce a directly sedative effect? In many instances, it undoubtedly stimulates the system, and seems even to produce a temporary vigour. Thus, a person fatigued by labour is excited to dance by hearing a joyous tune, with which, by habit, he has associated the idea of dancing. The impression is here first on the mental power, and the energy of the mind induces the motion of the body. If a person in these circumstances feels not that lassitude which he had just before experienced, and which is really the case, the temporary vigour he enjoys must ultimately be ascribed to the operation of sound, as the original exciting power. The depressing passions, however, are equally produced by the action of sound.

When these operate, we see not the least increase of excitement; nay, the system passes from the state of vigour to that of debility. And if we cannot conceive any power to be stimulant, excepting it excites the system, at least in the first stage of its action; we surely cannot reasonably conclude, that those combinations of sound which produce the depressing passions stimulate the system. It may, indeed, be alledged, that the sounds which seem naturally adapted to express grief or sorrow, operate precisely in the same manner upon the organ of hearing, by the impulse of certain undulations induced in the air, as the sounds which are expressive of joy; and that if one impression conveyed by these undulations is stimulant, so also must the rest. To this we would answer, that we cannot with precision estimate the *modus operandi* of any substance on the system, merely from a knowledge of the medium through which it operates: It is only by the effects which we observe to be produced, that we can form any just determination

termination relative to the power of any particular substance upon the system. In proceeding, according to this method, by induction, we stand upon firm ground. We are too little acquainted with the nature and properties of every substance, to be able *a priori* to say what will be their effects upon the animal body; nor will even a knowledge of their sensible qualities, in every case afford us any considerable assistance. Reasoning, then, from the various effects produced upon the human system by different combinations of sound, we must conclude, that their modes of operation are totally dissimilar, notwithstanding that they operate through the same medium.

Sound then appears to be an agent capable of acting upon the animal frame, and of producing material changes in the state of its organization, although it neither adds new matter to, nor abstracts any from the body. It operates directly upon the animal fibre. The sensations which it produces are transmitted to the
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mental power, and this last, by its reaction upon the animal body, produces a vigorous or debilitated state of the organization. It is obvious, therefore, that although sound is capable of exciting the system to action, yet it is an agent in many respects different in its nature from any of the preceding.

The fifth, and last, of the external powers which operate upon the body, is aliment. Under this term is included a great variety of substances, many of which seem to possess very dissimilar qualities. Alimentary matters have generally been divided into food, condiment, and drink. Food and drink must be reckoned among those powers, the operation of which is essential to the production and continuance of animal life. The wants of nature in this respect are indeed few, and easily gratified ; but the caprice and luxury of man have increased the list of alimentary matters to an enormous size. Many substances which have been employed as food, cannot be considered as favourable

vourable to health. The list of condiments also contains many others that are evidently pernicious ; and perhaps several of the fluids employed as drink are equally, if not more injurious. The modifications of alimentary matters by the art of cookery, also not unfrequently produce the most pernicious effects. We would not however, with stoical apathy, reject any wholesome or agreeable article of food, merely because nature can be supported without it : nor can we condemn any method by which a common article of diet is rendered more agreeable to the palate, for no better reason, than that life may be supported without the taste being in this manner gratified. By following the dictates of nature, and availing ourselves of experience, we may easily avoid employing any substance which is injurious to health. Yet it seems extremely difficult to point out the nature and properties of the different articles of food and drink, together with their effects upon the human body ; nor does it appear that this subject

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has yet been treated upon fully or properly. The limits, however, which we have prescribed in this essay, will not permit us at present to attempt a particular elucidation of this subject.

It is obvious, that alimentary matters are chiefly designed to repair the waste of the system, and that they are in fact the principal source from which the body derives new matter. Hence, although they are all undoubtedly stimulating, yet they cannot be supposed to act upon the body merely by their stimulant power. We shall endeavour to illustrate this by a brief view of the digestive process, which appears to be conducted in a great measure upon chemical principles. It must however be admitted, that food of every kind is capable of acting upon the organization by its stimulant power, independent of its use as furnishing new matter to the body. Thus water, which is perhaps the weakest stimulant employed as drink, is capable of exerting a stimulant operation even upon those who are accustomed to employ much more

more powerful fluid stimuli. Water is extremely beneficial in restoring a person under *deliquium animi*. The stimulating effect of food and drink is obvious to the feelings of every person. After long abstinence or fatigue, we find the body instantaneously invigorated on receiving a small portion of the mildest alimentary matter. Now, in this case, no part of the substance received into the stomach, whether solid or fluid, has been absorbed by the lacteals, and mixed with the circulating fluids. We can therefore only account for the effect on the supposition, that the matter employed stimulates the animal fibre of the stomach; and as the body is an indivisible whole, the operation is instantaneously extended to the most distant parts.

The principal benefit, however, derived from the aliment, is the new matter which it affords the system. The alteration which the food undergoes, and by which a proper nutritious matter is extracted from it, appears to be produced
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both on mechanical and chemical principles. The food is first mechanically divided, and mixed with the saliva, in the process of mastication. It is next transmitted to the stomach; and here probably it is in a small degree subjected to mechanical action, by the gentle alternate motions of the orbicular fibres of the muscular coat. It does not however appear, that the muscular action of the stomach assists in the digestive process. The operation in this viscus seems rather to be conducted upon chemical principles; and the chief use of what has been called the peristaltic motion of the stomach, appears to be, to propel the aliment, when sufficiently digested, through the pylorus.

In man, and all other animals, a fluid is secreted in the stomach, which appears in the different orders to vary in its quality. It is suited to the nature of the food which they are destined to employ; and the gastric fluid in each species appears capable of dissolving that kind of food which nature has provided for them. The gastric fluid of carnivorous animals easily dissolves

dissolves animal food, but has little effect on vegetable matters ;—that of the ruminating animals readily dissolves vegetable substances, but scarcely produces any change upon animal matters ;—while that of the human stomach is capable of dissolving, nearly with equal ease, both animal and vegetable substances.

It has been fully proved, by the experiments of Stevens, Spalanzani, and others, that the gastric fluid in man, and other animals, is capable of reducing the alimentary matters into a soft mass or pulp, independent of any degree of trituration, in the stomach ; because food inclosed in spheres and tubes, formed of metal or of wood, and by which the food was consequently defended from trituration, has been completely dissolved : And the same effect has been produced by the gastric fluid upon alimentary matters, even out of the body.

Powerful however as the solvent operation of the gastric fluid seems to be, it is incapable of acting upon the living animal
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body. We do not perceive any material difference between a piece of raw flesh recently cut from an animal, and the same substance in the living state; yet the gastric fluid easily dissolves the former, while it does not in the least act upon the latter, otherwise it would dissolve the stomach in which it is secreted. But no sooner has that degree of derangement taken place in the organization of any animal, by which it is rendered incapable of the action of the life-supporting powers, than it becomes susceptible of the action of the gastric fluid. That state of the organization which is necessary for life, is capable of resisting the operation of this fluid: and hence it is, as Mr John Hunter has remarked, that we find animals living in the stomach, or even hatched or bred there; but the moment that life is suspended in any of these, they become subject to the solvent power of the gastric fluid. We are certainly not possessed of any facts which enable us to point out the cause why animal matter, in the living state,

state, is capable of resisting the action of this fluid, when it so easily dissolves the same substance immediately after death.

But the saliva, and the succus gastricus, are not the only fluids which are employed in the digestive process. During its progress through the intestines, the alimentary matter is mixed with the bile, and the pancreatic juice. From the nature of the former, we are certain that its operation is in a considerable degree chemical: but it must be confessed, that we are too little acquainted with the nature and operation of the whole of these fluids, to point out, with any degree of accuracy, their precise effects, in extracting from the aliment a proper nutritious matter for the support of the body. In general, we perceive, that decompositions are effected, both in the aliment, and the animal fluids employed in the digestive process; and consequently various new combinations must be formed. The chemical nature of the digestive process, together with the other leading fact, that the aliment affords

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new matter to the system, furnish the most decisive proof, that aliment does not act merely as a stimulant to the body.

It will be here understood, that we readily admit, that proper alimentary matter possesses a stimulant power in a greater or lesser degree. In what we mean further to offer upon this subject, we shall therefore confine ourselves to some general observations on the nature of aliment, in two points of view : First, As possessing stimulant powers, differing from each other, perhaps in nature, and certainly in degree ; and secondly, As furnishing nutritious matter to the system.

Were we particularly to investigate the qualities and effects of the different articles of aliment, it would probably appear that some of those substances possess a considerable stimulant power, by which the action of the stomach is exerted, while they contain but a small proportion of nutrition ; and, on the contrary, other substances may contain a large portion of nutritious matter, which possess a low stimulant

mulant power : Yet it must be confessed, that it is not possible to ascertain the degree of stimulus in any substance merely from its sensible qualities. Acrimony, perfectly obvious, is not always a proof, that the substance in which it is found will more highly stimulate the system than other substances, the sensible qualities of which are comparatively mild. Were we to judge merely from the sensible qualities, we should conclude, that several of the acrid oils, as the essential oils of mint, cinnamon, and others, were higher stimuli than alcohol, or even opium. Experience, however, proves the contrary. These examples are taken indeed from the artificial stimuli; but perhaps varieties somewhat analogous to them, may be found among the substances which we employ as articles of food. It does not seem possible, therefore, to estimate the degree of stimulant power in any substance, excepting from the effects which we perceive it to produce in the animal economy. Again, another difficulty
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arises on this subject. A particular substance may actually possess a considerable degree of stimulus, and when first introduced into the stomach, may, in some measure, excite that viscus to action; but it is immediately mixed with the succus gastricus, and perhaps with other substances,—it undergoes a kind of decomposition, and new combinations are formed, which probably possess qualities exceedingly different from those of the stimulating substance received into the stomach. This, in many instances, must be the case; because, as we have already observed, the digestive process is, in a great measure, strictly chemical. In the new combinations which are formed, there may be different degrees of stimulus, by which not only the action of the stomach and bowels may be excited, but also the matter which is absorbed by the lacteals may possess different qualities in this respect; and hence the blood may become a more or less powerful stimulus to the sanguiferous system. That such alterations in the quality

lity of the circulating fluids may take place, cannot be denied, although alterations in the nature of the blood have not hitherto been particularly attended to, excepting in a few diseases, where the change upon this fluid is exceedingly great and obvious.

There are again other substances which may be received into the stomach,—transmitted to the intestines,—absorbed by the lacteals,—and mixed with the circulating fluids, without undergoing any change in the whole of this process. Of these we have a remarkable instance in the solid colouring matter of the rubia tinctorum, which is not only conveyed into the blood, but deposited in the bones, without having undergone any alteration. Sulphuric æther may also be mentioned as an example of a powerful stimulant being received into the circulating fluids, without undergoing any material change. It is a well-known fact, that vapours of this substance are in some cases thrown out of the body with the expired air, for thirty or

forty hours after receiving a large dose. The juices also of several vegetable substances, which are employed as articles of diet, or at least as condiment, seem to undergo little change in the digestive process, of which raw onions and garlick are striking examples.

From these observations two conclusions are obvious; First, That it is extremely difficult to ascertain the degree of stimulus which many substances exert on the fibre of the stomach and alimentary canal; because it appears, that in various instances the degree of stimulus cannot be determined by the sensible qualities; and it is equally impossible, in many cases, to ascertain what degree of stimulant power is possessed by the new compound formed in the digestive process. Secondly, It appears, that those substances which are most easily digested, do not, in many cases at least, possess so high a stimulant power as the more indigestible. Digestion, strictly speaking, is the change of certain principles contained in the alimentary

mentary matters, into proper chyle, fit for the nutrition of the system. We clearly see, that some of the most powerful stimulants that are ever received into the stomach, and which are commonly employed as drink, condiment, or medicine, do not undergo this change, or at least the alteration which takes place in them is only partial. From hence, then, we cannot infer, that those animal and vegetable substances which experience shews to be the most proper and nutritious aliment, are the most easily digested, or the most highly stimulant: We must rather, and with more reason, conclude, that those which are easily digested possess a degree of stimulus more exactly suited to the state of the organization or excitability in the fibre of the stomach, than the more indigestible; while these latter possess either too high or too low a stimulant power.

It must, however, be again remarked, that a mere stimulating quality, capable of exciting the fibre of the stomach, in

whatever degree it may exist in the alimentary matter, is not sufficient to account for the digestive process, nor can the degree of such a mere stimulant power be the chief cause why one substance is more easily digested than another. For, if it is true that the solution of alimentary matters by the succus gastricus is effected upon chemical principles, it will follow, that the peculiar qualities of this fluid are of much greater importance in the digestive process, than the degree of stimulus possessed by the aliment. For it is certain, that the succus gastricus is capable of dissolving the aliment, independent of any action in the animal solid. It may be indeed alledged, that of two given substances the one may be more easily digested than the other, because that which is most easily dissolved possesses a degree of stimulus to excite the action of those vessels in which the gastric juice is secreted; and that the substance which is not so easily digested, does not possess a sufficient degree of stimulus to produce this effect.

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We may readily admit, that the aliment may stimulate the vessels on the surface of the stomach, upon principles merely mechanical. Upon such principles, it is evident, that the saliva is excreted in larger quantity during mastication than at other times; but this reasoning, however plausible, certainly does not apply in all cases, in explaining why one substance is more easily dissolved in the stomach than another; because, if different species of aliment, as we have formerly observed, are inclosed in spheres or tubes, the gastric fluid is found to act more powerfully upon some than others. In the stomachs of carnivorous animals, vegetable matters are scarcely acted upon; — in the merely herbivorous, animal matters are not dissolved; — and in man, the degrees of solution in different substances exceedingly vary. Now, in all these cases, the mechanical action, applied to the surface of the stomach by the tubes or balls, is precisely the same: besides, as we have said, the gastric fluid extracted from the body and placed *in vitro*, exhibits

bits the same variety of effects upon different substances. And, in this case, the action of the gastric fluid is not assisted by that of any stimulant power, whether mechanical, or of any other kind. The secretion of a proper fluid to effect the solution of the alimentary matter, depends on the proper state of the circulating fluids from which the gastric liquor is secreted, and the state of the secreting organs; and both of these must ultimately depend on a due degree of excitement being maintained in the system at large; and this can only be effected by the natural agents or exciting powers being employed in a due proportion, by which the organization is preserved in the healthy state. The gastric fluid, however, being thus properly formed and secreted in due proportion, its action on the alimentary matter is, as we have said, strictly chemical. Hence then it is clear, that we cannot ascribe the peculiar solubility of any substance in the stomach to its possessing a high degree of stimulant power; nor in any great measure

sure to the degree of stimulus which it possesses, but rather to the quality of the gastric fluid, and to the quantity of the alimentary matter being justly proportioned to the quantity of the solvent fluid which the stomach is able to furnish. It may be objected, that the appetite is increased, and the digestion promoted, by throwing into the stomach highly stimulating substances, as alcohol in various forms, and certain vegetable stimulants, as water-cresses, horse-radish, mustard, and others; to which may be added the whole list of stimulating substances employed in cookery, and especially in the formation of sauces. It must here be observed, that the operation of substances by which the appetite seems to be increased, cannot all be accounted for upon the same principles. A considerable number of substances in the list of condiments, and the peculiar modes of preparing food, by rendering the alimentary matter more agreeable to the taste, are in many instances the cause of our employing a larger quantity of food than

than we otherwise should do. In other cases it may be admitted, that highly stimulating substances may excite the action of the stomach, so as to enable us to receive a greater quantity of food than usual. But it may be justly doubted, whether the digestive power is in any case much increased by the use of such stimulants. Nor can it be supposed that the digestive power can be promoted by their use, excepting the excretion of the gastric fluid is increased by the r stimulant action. But here it must be also observed, that not only, as we shall presently show, their producing this effect is in many instances dubious, but also, if the effect is produced, the continued use of such stimulants must be extremely injurious. For it is not to be supposed that the system can, in a limited period, supply any given quantity of the gastric fluid. And the forcing out of the vessels an improperly prepared fluid, can never be supposed to increase the digestive power. Their continued use, therefore, can only induce

induce a general debility of the system. Within certain bounds, they may indeed be employed, without very obviously producing injurious effects. But when used in large quantity, and the practice persisted in, indigestion, and all the other effects of repletion, inevitably follow. Besides, the seeming appetite which is suddenly produced by mixing stimulating substances with our food, is not wholly to be ascribed to the excretion of a greater quantity than usual of the gastric fluid. For not only are we induced to swallow a large quantity of particular substances, from the taste being gratified, but powerful stimulants, by exciting the mere muscular contraction of the stomach, may force a quantity of the aliment through the pyloric orifice into the intestines, without having undergone that change which is necessary to the preparation of proper chyle. It may be readily admitted, that when the system is under debility, and the stomach and bowels are particu-

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larly affected, as in dyspepsia, and other analogous cases, the use of stimulants of various kinds, provided the degree of stimulus is properly proportioned, may excite a due action in these organs, and promote the excretion of such a quantity of the gastric juice as may effect the digestion of the food, the formation of a proper chyle, and consequently the removal of the general debility, by furnishing a sufficient quantity of nutritious matter to the system. But there is reason to suspect, that in these diseases too great a quantity of the more powerful stimuli is not unfrequently employed.

From the whole of these observations, the following conclusions may be fairly drawn. First, That the digestive process does not solely depend upon the stimulating power of the alimentary matter, but also on the relation subsisting in the laws of nature between various substances, and by which they are disposed to enter into chemical combination. Secondly, Excluding

ding from our consideration the mechanical stimulus of the aliment, arising from its bulk, or degree of consistence, we do not perceive that the stimulant power possessed by any substance can be determined merely by its sensible qualities out of the body. Therefore, thirdly, The degree of stimulus possessed by any given substance can only be determined by the effects which we observe it to produce on the body. And, fourthly, That in estimating the qualities of any substance as an alimentary matter, we can only ascribe to its stimulant power the property of accelerating the digestive process in a certain degree, and upon the principles already stated: excepting in the case of those stimulants which do not undergo any change in this process, and which may be absorbed by the lacteals in a mere state of mixture with other matters. But an instance of these last is perhaps not to be found among proper alimentary substances.

We go on, in the next place, to offer some general observations upon the second

mode in which alimentary matters act in the animal body: that is, as furnishing a proper nutritious matter to repair the waste which takes place in consequence of the various excretions. Upon this point, the first question that occurs is, What is the proper nutritious matter? If this question were clearly solved, it might perhaps seem easy to determine, in the second place, what species, or individuals, among the various kinds of aliment, furnish the most proper or the largest quantity of nutritious matter. There are difficulties, however, which cannot be easily overcome, attending the solution of both these questions.

With respect to the first, What is the proper nutritious matter? The late ingenious Professor Cullen has endeavoured to prove, that it is formed of the acid, oil and saccharine matter which we find, in the more or less combined state, in vegetables. Observing that the greater number of animals which are employed as aliment derive their whole support from vegetable

getable matters, he considered it as reasonable to conclude, that the proper nutritious matter was ultimately to be sought for in the vegetable kingdom. As an acid is found in many vegetable substances which are employed as aliment;—as saccharine matter is either originally present, or may, by certain processes, be evolved in the most nutritious vegetable matters;—and as an oil is very generally present, or may be extracted from the most of these;—he concluded that they together formed the proper nutriment of animal bodies. To these he was inclined also to add, the vegeto-animal gluten which Beccaria had discovered in a considerable number of vegetables, and which especially abounds in some of the most nutritious, as in wheat. This, as a substance exceedingly analogous to animal matters, or rather as being always found in animal bodies, may with some reason be considered as proper nutriment. But Dr Cullen further observing, that acids, oils, and saccharine matter, are never found

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in the separate state in the blood, or other animal fluids, at least when in health; he therefore concluded, that the chyle was formed by an intimate mixture of these principles. Now, although this theory cannot be admitted, and especially in that latitude to which Dr Cullen seems to have extended it; yet justice compels us to observe, that it had a considerable degree of plausibility at the time when it was formed, and that it was offered with that modesty and diffidence which always mark true genius. We may even go farther, and admit, that in some instances, particular mixtures, formed of two or more of these substances, may be received into the sanguiferous system. But a more accurate chemistry, and a more rigid analysis of both animal and vegetable matters, than was known at the time when Dr Cullen wrote, lead us in some respects to speak with more certainty, and in others with a greater degree of hesitation, concerning the forms of those substances which are extracted from

from animal and vegetable matters to supply the body with nutrition.

We find, that the principal constituents of animal and vegetable substances, are different combinations, in various proportions, of carbone, hydrogene, oxygene, and azote; the last being generally in a greater proportion in animals than in vegetables. The whole of these are indeed found in the acid, oil, sugar, and vegeto-animal gluten which Dr Cullen supposed formed the nutrition of animals; yet we cannot say that a mere mixture of these forms the chyle, because in that decomposition which takes place in the alimentary matters when mixed with the gastric fluid, it is impossible to determine what new combinations are formed. Nor is it reasonable to suppose that nothing more is effected in this wonderful process than the formation of a mere emulsion, by the mixture of an acid, an oil, saccharine matter, and a portion of vegeto-animal gluten. Besides, there are other parts of vegetable substances which may furnish several of
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the constituents of animal bodies, as well as the previously formed acid, oil, or saccharine matter. Nor are we certain that those constituents of animal bodies which we obtain as the last result of analysis, are themselves strictly simple. It has been alledged, that carbone is a compound substance, formed of hydrogene and azote. This, though perhaps not fully proved, is at least possible. And the same may be the case with several others, which, in the present state of our knowledge, are necessarily considered as simple bodies. Hence various decompositions and new combinations may be formed in the digestive process, with which we are totally unacquainted. There are also other substances beside those which we have just mentioned, which must be considered as constituent principles of animal bodies: As the phosphate of lime, which forms so considerable a proportion of the bones; iron, and several saline matters, which are uniformly found in the fluids. Now the whole of these are either received into the
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body ready formed, or they are produced in the system by the combination of their various constituents. To take, for the illustration of this subject, the phosphate of lime for our example. From the great quantity of this substance in the bones, a considerable proportion of which we know is daily carried off by excretion, it is clear that a daily supply of it is required; and either the substance already formed, or its constituents, are introduced into the system, and are a part of the true nutritious matter. Now the phosphate of lime may be received into the body already formed: Yet we do not perceive any source from which in this state it can be derived. It exists, indeed, both in animal and vegetable matters. But it is in a very small proportion in vegetables; and the quantity is also exceedingly minute in those parts of animal bodies which we employ as aliment. In fact, it is only found in considerable quantity in the bones. It is equally certain, that neither this compound salt, nor any of its constitu-

ents, as far as we know, excepting oxygen, are contained in the vegetable acids, oils, saccharine matter, or vegeto-animal gluten, in which Dr Cullen supposed he had found the whole of the nutriment, or constituent principles of animal bodies. We are almost reduced to the conclusion, that the phosphate of lime is formed in the animal system. And admitting this, we are still involved in the greatest difficulty, in order to account for the introduction of its principles into the body. The phosphoric acid, one of its constituents, abounds in the animal system. It is found in the urine, and other fluids, united with different bases, as soda, ammoniac, and lime. It is also found in the dissolved state, its presence having been frequently detected in the stomach. This circumstance of the uncombined phosphoric acid being found in the body, seems to warrant the conclusion, that it received its origin as an acid there. But in this case, we are totally at a loss to account for the introduction of the phosphorus,

rus, from which it must be produced, unless it may be supposed that phosphorus itself is not a simple substance, but formed of constituents with which we are yet unacquainted. We are equally at a loss to account for the introduction into the system, of the lime, the basis of this salt; because we do not conceive that it can be found in such quantity in any alimentary matter, as to produce so large a portion as must be daily forming in the system, the quantity of which we can in some degree estimate, from our knowledge of the quantity daily carried off in the excretions. With respect to the iron that is found in all the red-blooded animals, and in a very great proportion of vegetables, it is now a very generally-received opinion among chemists, that it derives its origin from the vegetating and animalizing processes. Of the saline matters, it is highly probable that the ammoniac is formed in the animal system. Mankind indeed may receive a small quantity of this salt in the juices of other

animal matters. But the greater proportion of the ammoniacal salt contained in the animal matters which we employ as aliment, must be either decomposed or separated in the various methods of preparing our food. That a considerable quantity of ammoniac must therefore be continually forming in the animal system, seems clear; and this must more especially be the case in those of the inferior orders, which are wholly nourished by vegetable matters. There is also some reason to suspect, as we have formerly hinted, that soda is formed in the animal system. We find it united with oil and mucus in the bile, and it is also found in some other of the animal fluids. Nor can we suppose that this alkali is furnished by the muriate of soda, which we employ as a condiment, because it is also found in the bile and other fluids of various animals, who never receive any of the muriate of soda. We must therefore conclude, that this salt also is formed by the animalizing process.

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In attempting to account for the manner in which the daily waste of the system is supplied by new matter, we must not wholly confine ourselves to the digestive process. In treating upon respiration, we have observed, that it is doubtful whether one of the constituents of the body, viz. oxygene, is not received during the respiratory process. And it has never been determined, whether particular substances may not be inhaled by the absorbent vessels on the surface of the body. In diabetes, it is generally admitted, that a very considerable absorption takes place by these vessels. This, indeed, constitutes disease. But it is not unreasonable from hence to infer, that in the healthy state an absorption may also be continually going on, and by which the body may be supplied with some of its constituents. This suggestion may in some degree be supported by analogy, drawn from the vegetable kingdom. It is very generally supposed, that vegetables receive a considerable

considerable part of their nutrition from the atmosphere by absorption.

From these observations, the difficulties attending the solution of the questions which we have stated, are sufficiently obvious. When we find that the changes which take place upon the alimentary matters are so great and various; and that these changes are not only produced in the digestive process, but also in the blood, and perhaps in many of the secreting organs; we must conclude, that it is almost impossible to point out the particular parts of any animal or vegetable substance, from any mode of examining the constituents of that substance, or the constituents of the animal body which is nourished by it. It is, indeed, natural to suppose, that animal substances will furnish a greater quantity of nutritious matter than vegetables; and that it will be more easily assimilated to the animal body, because it approaches so nearly in its nature to that body which it is employed to support. But if we had no other evidence that

that animal matters are more capable than vegetables of furnishing nutrition, than merely the similarity of the animal matter to the body which receives it, we should have little reason to draw such a conclusion: First, Because death has induced a very considerable change upon the animal matter which we employ as aliment; and, *a priori*, it is impossible to determine how great the difference may be between living and dead animal matter. Secondly, The animal aliment undergoes another and equally important change, by the various modes of cookery to which it is subjected. And thirdly, Animal, as well as vegetable matters, appear to undergo a total decomposition in the digestive process. From these facts it is clear, that if we had no other evidence on the point, we could not determine, that of equal quantities of animal and vegetable substances, the one would furnish more nutritious matter than the other. Both animal and vegetable substances contain, though in different proportions, the constituents

stituents of animal bodies. From simply considering their nature or their differences, as animal and vegetable matters, we see no reason why the nutrition proper for man might not be extracted from the one in as large a quantity as from the other, or why the one should be more easily assimilated to the animal body than the other. The constituents of an ox do not materially differ from those of man: Yet we see the former animal may be supported and fatted wholly with grass, a vegetable which will afford very little nutrition to man. By other modes of evidence we perceive, indeed, that animal substances contain a greater quantity of nutritious matter, and are more easily assimilated than vegetables. If equal quantities of any animal, and the most nutritious vegetable substance, are received into the stomach, the person employing them will derive, *cæteris paribus*, a greater degree of strength and vigour from the use of the animal than the vegetable matter. Here the proof depends upon a simple and ob-

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vious fact. Upon the same principles we may in some measure ascertain the different proportions of nutritious matter furnished by the various animal and vegetable substances which are employed as articles of diet. And as in every instance it will be found that animal matters give a greater degree of strength and vigour to the system than vegetables, we may justly conclude, that animal matters contain a greater proportion of proper nutrition than vegetable substances. It may however be questioned, whether a larger proportion of vegetable matters, especially of the more nutritious, will not communicate as great a degree of vigour to the system as a smaller quantity of animal food, and particularly to persons who are habituated to its use. With some restrictions, this question should probably be answered in the affirmative. Animal matters, however, do not only contain a greater proportion of nutritious matter, but they are also more easily assimilated to the animal system. The proof of this is drawn from the various

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structure which obtains in the intestines of the carnivorous and phytivorous animals. In the carnivorous animals we find only one stomach, and the intestines are comparatively short. The phytivorous are frequently supplied with two or more stomachs, and the intestines are extended to a great length. It is evident from these varieties in the structure of the alimentary canal, in animals which are destined respectively to live on these different species of aliment, that animal matters are digested in a shorter period than vegetables. The intestines in man are of a medium proportion between those of the merely herbivorous and carnivorous animals: And this structure indicates, along with other facts, that nature has designed both animal and vegetable matters to be employed as the aliment of mankind. It ought however to be remarked, that other reasons have been assigned, beside this that we have just mentioned, for the peculiarities in the structure of the intestines of those animals which respectively live upon
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animal and vegetable diet. It has been supposed, that the shortness in the one case, and the length in the other, are designed to counteract certain inconveniencies which attend the fæces produced from these different kinds of aliment. In particular, as the fæces in man and the carnivorous animals are extremely foetid, it is supposed that they have so great a tendency to putrefaction, that it would be extremely inconvenient if they were long retained in the body. Hence a short intestine is provided, to facilitate their expulsion. On the other hand, as a vegetable diet has a considerable tendency to produce laxity, perhaps from various causes, it is alledged, that the length of the intestines in phytororous animals is designed to prevent the alimentary matters from being too rapidly carried off, and consequently to allow a sufficient period for the separation and absorption of the nutritious matter. Allowing these arguments their full force, we may also reasonably admit, that the length of the intestines in different animals is

also proportioned to the easy or difficult assimilation of the aliment which they are designed to employ.

In attempting, then, to ascertain what particular parts of any substance are extracted as nutritious matter, we find ourselves totally at a loss. We observe, that a chemical decomposition of the alimentary matters takes place, and that new combinations are formed in the stomach by the agency of the gastric and other fluids. When the aliment is propelled into the intestines, it undergoes a farther change, by being mixed with the bile, and the other fluids which are there secreted. New combinations are also there formed, with the nature of which we are by no means acquainted. After these alterations have taken place, the chyle is extracted from the general mass, and absorbed by the lacteals; and with respect to the nature of this fluid, we possess scarcely any information. When the chyle is mixed with the blood, it is destined to undergo other modifications, of the nature

ture of which, and the mode of operation by which these alterations are produced, we are entirely ignorant. Beside all this, various alterations are taking place in the different secreting organs; and, as we have recently observed, a number of substances, some of which are known to be compounds, and others which at present are considered as simple bodies, appear to receive their origin by unknown operations carried on in the animal œconomy.

On a subject so completely involved in obscurity, there is abundant room for forming hypotheses. But as from these no possible benefit can result, I shall decline the task. We have dwelt thus long upon this subject, to shew the insuperable difficulties under which, in the present state of our knowledge, it labours. With respect to the first question, What is the proper nutritious matter by which animal bodies are supported? we must content ourselves with observing, that the various constituents, of which animal bodies are formed, are extracted from the alimentary matters,

matters, and, by the different stages of the animalizing process, already mentioned are applied to their various uses in the body. In some cases, perhaps, they may be received in a compound state, and may in that form be proper for immediate application as a part of the system. In other cases, and which perhaps are the most frequent, they are reduced to more simple principles, and enter into new combinations, before they become a part of the animal body to which they are assimilated. With regard to the second question, What species or individuals among the various kinds of aliment, furnish the most proper, or the largest quantity of nutritious matter? It appears that we have no data by which to decide, excepting the obvious facts, that one substance is more easily digested, and communicates a greater and more lasting vigour to the system, than another. And the knowledge of these facts can only be derived from observation and experience.

Having thus briefly considered the nature

ture and effects of the external agents, the action of which appear necessary to the production and continuance of life, we proceed to take a short view of those internal powers which operate upon the organization, and by which the phenomena of life are supported.

Of the internal agents, we first take notice of the blood. This substance, which forms the general mass of the circulating fluids, appears chiefly destined to serve two offices in the system. First, To induce a farther change upon the chyle, or nutritious matter received from the aliment; and in the course of the circulation, to deposite this new matter in every part of the body, to repair the waste which the system is perpetually suffering, and to furnish matter for the secretion of various fluids necessary to the animal œconomy, such as the bile,—the succus gastricus—the saliva, &c. Secondly, To stimulate the heart and arteries, by which they are excited to action; and hence the circulation is produced.

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The constituents of this fluid in the healthy state have of late years been ascertained with considerable accuracy; yet we cannot say that much information has been derived from these inquiries, with respect to the fitness of the blood for either of the two purposes we have mentioned. The coagulable lymph, or fibre of the blood, seems not to differ in its nature and qualities from the matter of the muscular fibre. Hence we may conclude, that it is a substance prepared in the sanguiferous system, to supply the waste of the animal fibre. With respect to some other parts, it is not easy to determine, whether they are designed to be deposited in any part the body, or whether they have not already been employed, and are to be considered as excrementitious, and intended to be carried off in the urine and perspirable matter. Such, for example, are the saline matters which are found in the blood, as the muriate of soda, and the phosphates of soda, ammoniac, and lime.

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But without entering further into considerations of this kind, it is sufficient here to show, that the blood does in fact effect the purposes we have mentioned. With respect to the first, it is universally admitted, and we need not therefore enter upon any particular proof; it will be sufficient to observe, that the state of the organization will be liable to considerable variations, in proportion to the quantity and quality of the nutritious matter contained in the blood. The formation of a proper nutritious matter must necessarily depend on the previous state of the organization, together with the quality of the ingesta. The due secretion of the gastric and other fluids employed in digestion, the formation of a proper chyle, and the further animalizing process which takes place in the sanguiferous system, must depend on the state of the solids. Hence any attempt to restore a debilitated system must be in vain, unless we can, by nutritious matters, reproduce a healthy state of the organization.

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With respect to the second use of the blood, that it is a stimulus to excite the action of the heart and arteries, seems clear; first, because these organs are evidently susceptible of the action of stimuli, as they are abundantly supplied with the muscular and medullary fibre; and secondly, because the usual effect of stimuli is produced upon the heart and arteries, viz. they are excited to action, and we perceive no agent immediately operating upon them, except the blood. We readily admit, that the nervous stimuli have also a considerable influence on the muscular fibre of these parts, because it is well known that the systole and diastole of the heart become more or less frequent, in a given period, in consequence of various passions of the mind. In these cases the mental energy operates on the muscular fibre of the sanguiferous system, through the medium of the nervous stimuli. It has been also alledged, that the muscular fibre of the heart may be subjected to the determination of the will,

will, so as to become in some degree a voluntary muscle. This in particular has been asserted by Fontana, as a power which he himself possesses. Whatever may be in this, it appears that the action of the heart and arteries is effected by the joint operation of the nervous stimuli and that of the blood. With the latter alone we are at present concerned.

Variations may take place in the action of the heart and arteries, from two causes. First, a derangement in the organization, by which the susceptibility in the animal fibre for the action of stimuli is in too great a degree increased or diminished. Of the former we have evident examples, in many cases of disease, in which we observe an increased action in the sanguiferous system. We cannot perhaps, in any of these cases, point out the nature of the change which has taken place in the organization; but in every instance it is attended with universal debility in the body. Of the latter we have examples in many cases of diminished action in the

heart and arteries, and in some instances we can clearly point out the nature of that change which has taken place in the organization, and by which it has become less susceptible of the action of stimuli than is necessary for the healthful state. The ossifications which frequently take place in old age in the valves of the heart, and in the large blood-vessels as they enter the heart, are striking examples of this kind. In these cases the proper matter of the animal fibre has in the usual course been carried off, and its place supplied by osseous matter, a substance nearly unsusceptible of the action of stimuli. Whenever this alteration takes place to a certain extent, the circulation of the blood is prevented, and the animal functions must entirely cease. Those instances in which the muscular and medullary fibre, the cellular substance, &c. are changed into bony matter, furnish an additional proof, that no material change takes place in the system without the organization

ganization having undergone some alteration.

Secondly, Variations in the action of the heart and arteries may be caused by the state of the blood. That this fluid may be subject to material alterations with respect to its qualities, cannot be denied; and from hence considerable varieties must follow in its stimulant power. In particular, it may be supposed, that very different proportions, of the saline substances which are uniformly found in the blood, may exist in it at various periods; and hence its qualities as a stimulant may be increased or diminished. But these variations in the constituents of the circulating fluids, as we have already observed, have been so little attended to, that it is impossible to speak of them with any degree of certainty.

It does not seem possible to assign the cause of the stimulating quality of the blood. Perhaps we ought to content ourselves with observing, that in the healthful state the blood is a mixture exactly fitted

fitted by nature to stimulate the organization of the sanguiferous system. The blood is preserved in a proper state to effect this purpose, by the supply of new matter which it receives from the aliment, and by the change which takes place upon it in the process of respiration. That a supply of new matter from the aliment is necessary to preserve the circulating fluids in the healthful state, is too obvious to need proof: And that the process of respiration is equally necessary, is evident, because the abstraction of respirable air for a short period causes death. In this last case, we have so striking an example of the blood in a short space undergoing some change, by which it is rendered incapable of stimulating the sanguiferous system, that it may not be improper to add a few observations upon the subject.

We have already observed, that the effects which appear to be produced in respiration are, first, The separation of a quantity of carbonaceous matter from the viscous mixture which is called the blood;

blood ; secondly, The evolution of heat ; and thirdly, A change in the colour and qualities of the blood during its passage through the lungs. But can we suppose that the mere retention of a small quantity of carbonaceous matter in the system, or the diminution of sensible heat in the animal body, can be the immediate cause of sudden death during the abstraction of oxygene ? It must, however, be remarked, that the change which takes place in the blood, by which it is rendered a proper stimulus to the heart and arteries, is certainly in part effected by the abstraction of carbonaceous matter ; and probably that change is also in a great measure owing to the continued evolution of heat during respiration. The sensible heat of the system in general during the abstraction of oxygene for such a period as will cause death, is not so far diminished as to produce any possible inconvenience. Nay, in some cases, as in suffocation by the carbonic acid gas, it appears that the sensible heat of the body is rather increased. But, according

according to the experiments of Dr Crawford, it appears, that the relative capacities of the venous and arterial blood for receiving heat are as twenty to twenty-three. By the alteration then which takes place on the blood during respiration, the arterial blood acquires this increased capacity. Now, it is a known law of heat, that if two bodies of different capacities, and at different temperatures, are brought in contact, that body, the absolute heat of which is greatest, will raise or diminish the temperature of the body which has the least capacity, much more than the latter can alter the temperature of the former; and this increase or diminution will be in the direct ratio of their capacities. Now the blood, during its passage through the lungs, not only acquires an increased capacity, or has its absolute heat augmented, but, by the evolution of heat in the lungs, its temperature or sensible heat is also increased; and consequently, on being applied to the heart, it must give out a much greater quantity of heat than it

it could have done before it had undergone the change of which we are speaking. It must further be observed, that the heat thus communicated to the muscular fibre of the heart by the blood returned from the lungs, is not merely in proportion to the respective temperatures or sensible heat of the blood and muscular fibre, but also to the enlarged capacity or absolute heat of the blood. We might proceed to illustrate this subject, by employing numbers to denote the respective temperatures, and relative capacities for heat, of the muscular fibre, and the venous and arterial blood; but experiments are yet wanting to enable us to employ the numbers which really express the capacities, and perhaps also the respective temperatures. I shall therefore content myself at present with suggesting, that there is the highest degree of probability to suppose, that the qualities which the blood acquires during its transmission through the lungs, by which it is fitted to be a proper stimulus to the heart and

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arteries, depends on the abstraction of carbonaceous matter, and the quantity of heat which it becomes able to give out to a substance of a lower temperature. And lastly, As we have observed that the immediate cause of death, when produced by the abstraction of oxygene, is, that the blood is no longer a proper stimulus to excite the action of the heart and arteries; now, if what we have here suggested is founded on facts, it will follow, that the beneficial effects derived to the animal system must be confined to the consumption and carrying off the carbonaceous matter and the evolution of heat; consequently, although the oxygenous gas may itself stimulate the lungs, yet it is not to be considered as producing this effect on the system at large, but that it is the chief source by which the system is supplied with the stimulus of heat.

The sexual intercourse is the second internal power which we have mentioned. Though not essential to animal life, it is absolutely necessary for the continuation
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of the species, and it is a powerful stimulant to the system. The mental energy in this case seems to co-operate with a material stimulus. Excited by the ideas of beauty, real or supposed, in a particular object, and stimulated by a liquor secreted from the blood, and lodged in the vesiculæ feminales, or perhaps existing in the blood *, man, generally speaking, during a certain period of life, feels himself under the influence of an irresistible impulse. The exhaustion which follows the action of this power, clearly illustrates our general doctrine, with respect to the operation of stimuli. When the passion is too freely indulged, it is a well-known cause of universal debility.

The third internal power which operates upon the body, is muscular motion. This appears to be absolutely essential to the continuance of animal life. If this sti-

The late Mr John Hunter, in opposition, I believe, to the opinion of most anatomists, has denied the previous secretion of the semen.

musculus does not act in a sufficient degree, i. e. if only partially abstracted, disease certainly follows: which, though perhaps slow in its progress, infallibly shortens the period of human existence. Examples of this kind fall daily under our observation, in people whose lives are sedentary, whether from necessity or habitual indolence. The contrary extreme, or excessive labour, produces a similar effect. In both cases, a debilitated state of the organization is induced.

It is not our intention to attempt an explanation of the cause of muscular motion, any farther than, as we have already observed, that muscular motion obviously depends on the nervous stimuli: for although contractions can be produced by the action of mechanical or chemical stimuli, in the muscular fibre, both in the living state, and for some time after the apparent death of the animal, and which contractile power is not possessed by the medullary fibre; yet, as we have already hinted, all the motions of the body in the living

living state, both voluntary and involuntary, depend on the operation of the nerves, which, by their universal distribution throughout all the muscles, unite the whole into an indivisible organized system, of which the sensorium commune is the central point.

We would not wish to decry the labours of those who have endeavoured to ascertain the cause of muscular motion; yet it ought to be remarked, that every attempt of the kind has hitherto been unsuccessful. The supposed nervous fluid, —an invisible æther, —and electricity, have all been in vain employed. Nor does the very singular and curious influence recently discovered by Galvani seem to throw any further light upon the subject*. In the present state of our knowledge

* The following quotation is given merely as an example to what extent ingenious men can indulge themselves in fanciful hypotheses: "Does not muscular contraction, or intumescence, really depend upon the combination of oxygene with hydrogene and azote," (separately and combined in various proportions), "in consequence of a
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ledge at least, we must rest satisfied with the simple fact, that such a power of motion is possessed by organized matter; and that this motion is produced by the operation of stimuli. It will follow then, that the proper exercise of this motion depends upon a certain state of the organization, and the operation of the natural agents in due proportion. If those essential stimuli, heat, air, and aliment, are in any degree abstracted, a proportionate degree of weakness will be produced in the

“ sort of explosion produced by the nervous electricity?
 “ According to this hypothesis, animal motion, at least
 “ that of animals analogous to man, would be produced
 “ by a very beautiful pneumatic machinery; and our
 “ nervous and muscular systems may be considered as a
 “ sort of steam engine. This hypothesis, though not per-
 “ haps at this moment capable of strict proof, is extremely
 “ probable, since it is countenanced by every observation
 “ and experiment yet made on the subject.” Vid. Obser-
 vations on the nature and cure of Calculus, &c. by Dr
 Beddoes, page 258. Can any one seriously believe that an
explosion of oxygene and hydrogene takes place in every in-
 stance of muscular contraction? At the beginning of the
 present century, the human frame was supposed to be a
 hydraulic machine. We are now changed into steam-en-
 gines, or perhaps into pneumato-chemical apparatus.

the organization, and the power of motion is considerably diminished. It is equally true, that the abstraction of these stimuli to a certain degree will produce the most violent spasms and convulsions, i. e. morbid muscular motion. These irregular motions of the muscular fibre, evidently depend on a debilitated state of the organization, produced, in this case, by the abstraction of stimuli. A well known fact, which is every day seen in the shambles, will clearly illustrate this point. When an animal is put to death by the abstraction of blood, its life terminates in strong convulsions. Here the irregular motion of the muscular fibre, is a consequence of that debility which is induced by abstracting the usual stimulus of the blood.

But as the power of motion in the muscular fibre is diminished in proportion to the abstraction of the usual stimuli, and is totally destroyed if these stimuli entirely cease to act upon the body; so also that power of motion may be diminished and destroyed,

destroyed, by the same stimuli acting with too great force, or by the more powerful artificial stimuli, as alcohol, opium, &c. when operating to a certain extent. In this case debility is induced as well as in the former. The body in the first instance may be more highly excited, and the animal fibre may acquire a greater degree of vigour by the excessive action of stimuli; but in the ultimate effects we can observe no material difference in the debilitated state of the organization produced by the excessive action or abstraction of stimuli.

The principal point, however, to which we are here to attend, is, that the muscular motion itself, by whatever means produced, is a stimulus to the system in general. The operation of this power is necessary to effect, in a due proportion, all the secretions and excretions of the body. Hence muscular motion is essential to the healthful state, and, like every other stimulus, its excessive action is well known to be injurious. Whether any unknown
change

change takes place on the animal fibre by a too much increased or diminished muscular motion, it is impossible to determine. But it is sufficiently obvious, that a material alteration must take place in the organization, from too great an increase or diminution in the secretions and excretions which necessarily follow an extreme or diminished muscular action. By the first, the body is deprived too rapidly of matter; and by the second, those substances which have performed their destined use, and which ought to be carried off, are detained in the system.

The fourth and last of the internal powers which operate upon the body, is the mental energy. In every action of life the influence of mind upon the body is perceptible, and the most material alterations are produced on the organization by the operation of the more violent mental passions.

It is not our business to institute an inquiry relative to the nature either of the mind itself, or of that intimate connec-

tion which subsists between it and the body. That the greater part of our mental perceptions are derived from impressions made by external objects, and conveyed to the mind by the organs of sensation, is sufficiently evident; and that the mind reacts upon the bodily organization is equally obvious. The continued exertion of the mental energy is necessary to produce the action of all the voluntary muscles. Hence it seems clear, that the mental energy operates as an exciting power or stimulus to the bodily organization.

That exercise of the mental power which is termed thinking, is evidently stimulant to the material organization. The exercise of this function will protract the waking state, even when the body is much exhausted by labour. Thinking, however, like every other stimulus, produces that change on the organization which renders the body less susceptible of the action of stimuli. The universal lassitude which follows severe study, and which

which has been experienced by every person capable of intense thinking, sufficiently exemplifies this observation. But the continued exertion of this function will, like every other stimulant power, produce that degree of debility in the animal body, by which it becomes so much susceptible of the action of the various agents as to constitute the morbid state. Hence morbid watchfulness may be produced by intense thinking. The faculty of thinking appears then to be capable of producing very material alterations in the state of the animal fibre. When exercised in a moderate degree, it gives energy to the system; but if its action is too much increased, it will produce all the various stages of debility, and will not only accelerate the destruction of the system, but, perhaps, if acting in a very high degree, may produce sudden death.

But it is in the more powerful effects upon the bodily organization produced by the stronger passions, that we can discern the extraordinary influence of the

mental energy upon the body, and are, in some degree, enabled to ascertain the nature of its operation. The passions are naturally divided into two kinds: They have been termed the exciting and the sedative passions. Of the first kind are, confidence, hope, joy, love, anger, and hatred. Fear, sorrow, grief, and despair, are of the second kind. It will be generally admitted, that the first class stimulate, or produce a temporary energy in the system; and it is certain, that their continued action exhausts or debilitates the body. If operating in an excessive degree, they are capable of so far deranging the organization as to produce death. The effects of excessive joy or anger in this respect, are too well known to need exemplification.

The depressing passions, on the other hand, immediately debilitate the organization. The effects of fear or grief, if arising to any considerable degree upon the human body, are, loss of appetite, indigestion, and other symptoms of dyspepsia,

fia, diarrhoea, and that degree of debility which produces the morbid watchful state. The system also becomes more susceptible of the action of deleterious powers, as the contagion of typhus, &c. The same total derangement of the organization follows the excessive operation of these passions, as well as the former class. Thus excessive fear or grief has often produced death.

It has been alledged, that the depressing passions are only a diminution of the exciting passions, not emotions of an opposite nature * : That they are therefore to be considered as weak stimuli, and that their operation upon the body is the same as the abstraction of the necessary stimuli. This opinion is inadmissible; First, Because, as we have formerly observed, no power can be considered as stimulant, unless, when operating in a certain degree, it has the effect of producing energy in the system. But fear or grief, operating in any degree, produce debility.

Secondly,

* Vid, Element. Med. Brun,

Secondly, It is manifestly absurd to suppose, that grief is merely the abstraction of joy, or fear of confidence. We cannot avoid perceiving, that the depressing passions are not mere abstractions of stimulant agents, but are rather powers which operate with considerable force, directly inducing debility in the system. This class of passions, therefore, must be considered as sedative powers; and the conviction that they are such, naturally leads us to conclude, that there are other substances in nature which also produce a directly sedative effect upon the body. Such, perhaps, is the marsh miasmata, and the contagion of typhus.

In the prosecution of this Essay we have seen, that the human body, though formed of matter under various modifications, possesses a striking similarity in the organization of all its parts. Through the union of these parts by the universal distribution of the nerves, a complete and indivisible system is formed. And such is the unity of the body, that no power can

can possibly operate upon any part of it, without, in a greater or lesser degree, affecting the whole.

The body, thus formed, appears to be susceptible of impressions from a great variety of agents. A particular set of these, which we have styled the natural or healthful agents, by their operation upon the body, produce the phenomena of life. This susceptibility of impressions, which we observe in the body, we are constrained to ascribe to its peculiar organization. Every attempt hitherto made to ascertain the cause of this susceptibility, has failed. The utmost extent of our knowledge upon this subject, appears to be, that life, and all its various phenomena, are produced by the action of the healthful agents upon matter peculiarly organized.

The continuance of life, and the preservation of the healthful state, appear to depend upon the natural agents acting in a degree proportioned to the state of the organized matter. If these agents are partially withdrawn, a debilitated state
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of the organization is produced, in proportion to the extent and period in which these healthful powers are abstracted. In all these cases we see a progressive debility taking place, which finally terminates in death. The same effect is produced by the total abstraction, for a very short period, of all or any of those agents, the operation of which is essential to the continuance of life, such as heat, air, and aliment.

The same healthful stimuli, acting in too great a proportion, produce a derangement of the organization, which is also marked by debility, and which will also terminate in death. But this is always preceded by an apparently increased vigour in the system, unless the action of the stimuli is in an excessive degree. In this last instance, i. e. when the stimuli act in an excessive degree, death is speedily, and in some cases instantaneously, induced.

The debilitated state of the organization, whether produced by the abstraction

or

or excessive action of the natural agents, or of the artificial stimuli, differs not in its nature. Though produced by these opposite causes, it can only be removed by the same means, viz. employing the healthful and artificial agents in a due proportion. The distinction, therefore, between direct and indirect debility, seems not to be founded in nature.

When, by the due action of the natural agents, the body has acquired its highest state of vigour, i. e. during the period of manhood, the organization becomes less susceptible of the action of many stimuli. This arises merely from the vigorous state of the animal fibre. Habit may also, for a short period, inure the body to the action of certain stimuli, so as to render it necessary to employ a larger proportion, in order that the usual effect may be produced. But the animal system cannot be habituated to the excessive action of any stimuli. If their operation is increased in any degree beyond what is absolutely required to pre-

serve the healthful state, debility must be induced. In old age, man becomes more susceptible of the action of powerful stimuli than in middle life. Hence the supposition, that in advanced life an increased proportion of the artificial stimuli becomes necessary, appears to be without foundation.

During the progress of life, we observe various modifications taking place in the animal fibre, by the operation of the healthful agents. From infancy to manhood the waste of the system is repaired,—the animal fibre is recruited,—the matter of the body is increased,—and a firm vigorous organization is produced, by the operation of the natural agents, particularly aliment. From manhood to old age another change progressively takes place. The animal fibre becomes daily less susceptible of receiving new matter, till at length it is so far deranged that it cannot derive nutrition from the aliment. The action of the same powers which, from infancy to manhood, had increased

the vigour of the bodily organization, during the succeeding period produces decay, and their continued operation finally exhausts the system; and issues in death.

From the subjects on which we have treated, many important deductions might be drawn relative to medical practice; but this would lead us beyond the bounds we have prescribed. It may, however, be remarked, that the indivisibility of the body seems to deserve the most particular attention in the cure of diseases. It is alone, by attending to this fact, that we can properly distinguish between general and local diseases. It may be suspected, that in many cases local remedies are employed and depended on when the complaint is truly general, and can only be removed by producing a healthy state in the organization of the whole system.

That much more is to be expected in the cure of diseases from diet and other regimen, than from medicine, is generally admitted. It cannot, however, be denied, that this maxim is not sufficiently attended

attended to in the practice of medicine. From a due application of the healthful agents the most important changes may be produced in the animal body. To the operation of these agents alone can we look for the cure of all diseases of debility, and which include the greater part, if not the whole list of maladies to which human nature is subject. In no case of general disease, and there are few others, can a cure be expected from medicine alone, without a due attention to the diet and other regimen; but there are many cases in which the latter may remove disease without assistance from the former.

